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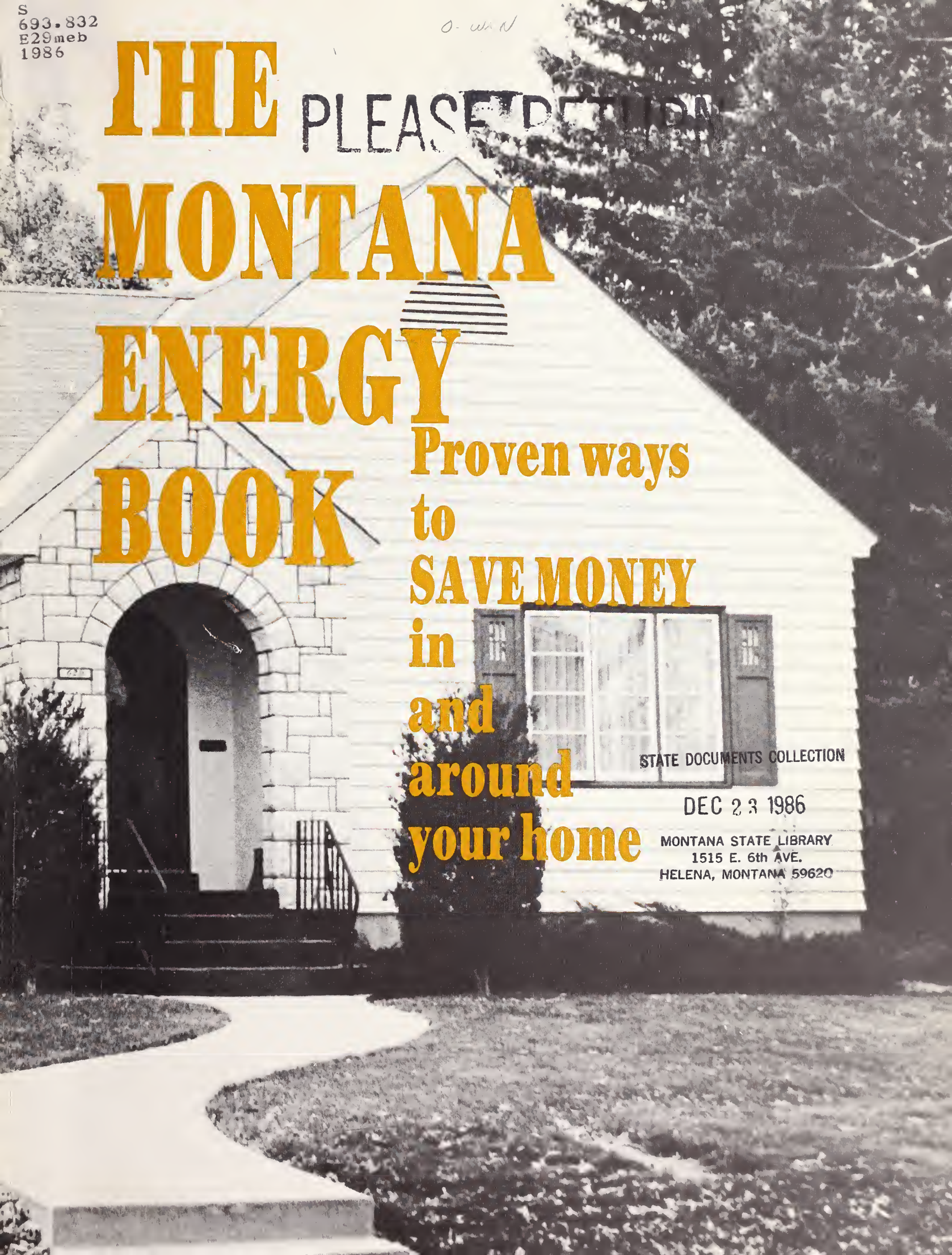
THE MONTANA ENERGY BOOK

Proven ways to SAVE MONEY in and around your home



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Dear Fellow Montanan:

The *Montana Energy Book* can help you reduce heating and cooling costs in your present home by 20 percent or more a year, and can make your home more comfortable as you save energy and money.

This book is designed to help take the guesswork and confusion out of selecting energy conservation improvements that give you the best return on your investment. It will help you determine which energy conservation improvements are do-it-yourself projects and which are jobs for a skilled contractor.

Included are tips on how to purchase energy efficient heating equipment, how to locate and prevent air leaks, how to insulate your floors and ceilings, and other conservation measures. Many of those discussed can be made for a very small investment. All of the improvements recommended are expected to pay for themselves in 7 years or less.

After you've taken the conservation measures listed here, pass this book on to a neighbor, or, fill out the "Good Neighbor Referral Card" at the end of this book and return it to us. We'll send a free copy to your friends and acknowledge your thoughtfulness in suggesting them.

The Montana Department of Natural Resources and Conservation

THE MONTANA ENERGY BOOK

MONTANA DEPARTMENT OF
NATURAL RESOURCES AND CONSERVATION

1520 EAST SIXTH AVENUE
HELENA, MONTANA 59620
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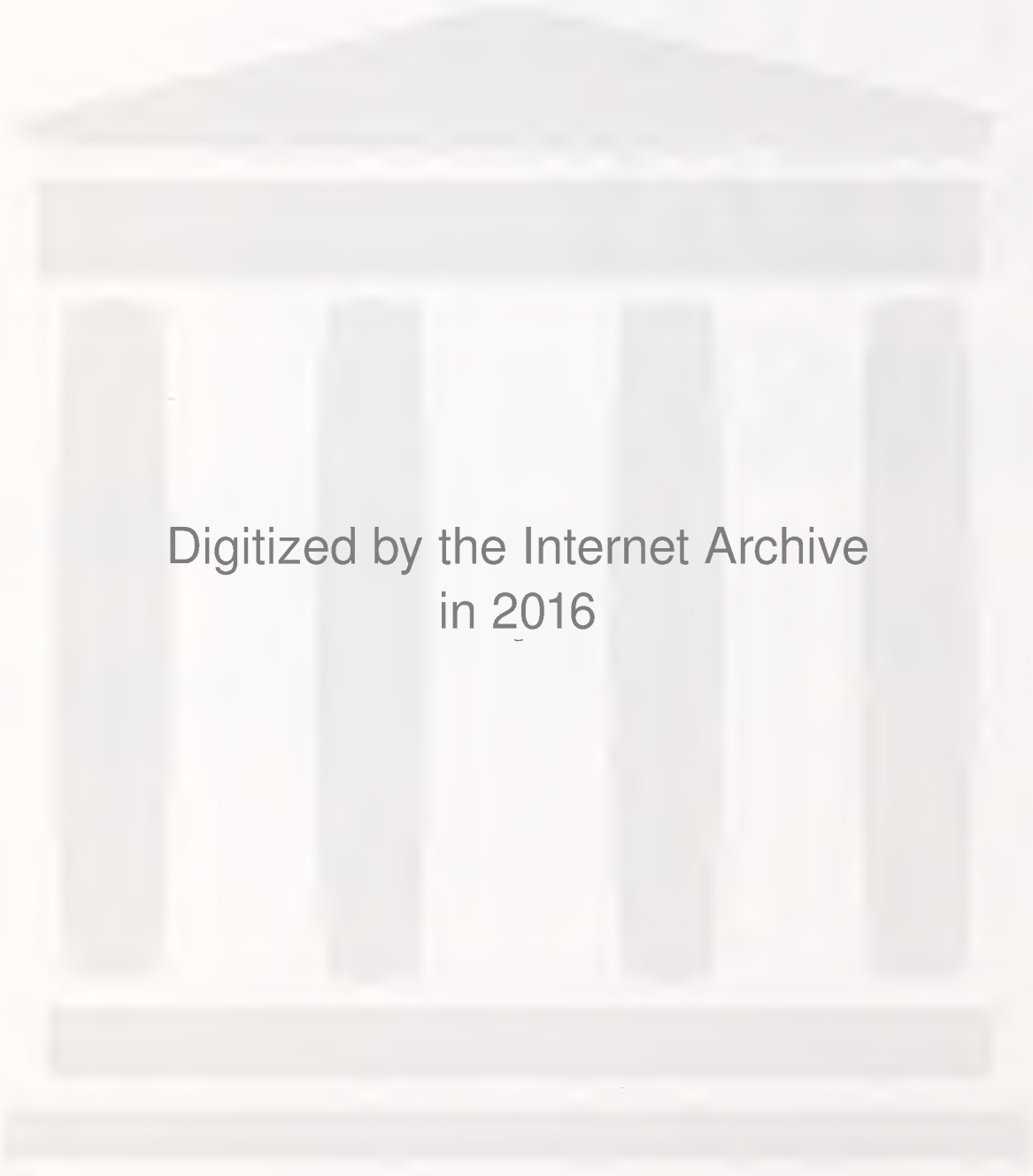
JUNE 1986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Jeff Birkby of DNRC's Energy Division adapted the text and supplied additional material. Mike Chapman and Brian Green of DNRC provided technical information. Peggy Todd edited the text; Margie Peterson did the word processing; Carole Massman and Gordon Taylor advised on production; Don Howard did the graphic design and layout; Jim Bond provided the photography.

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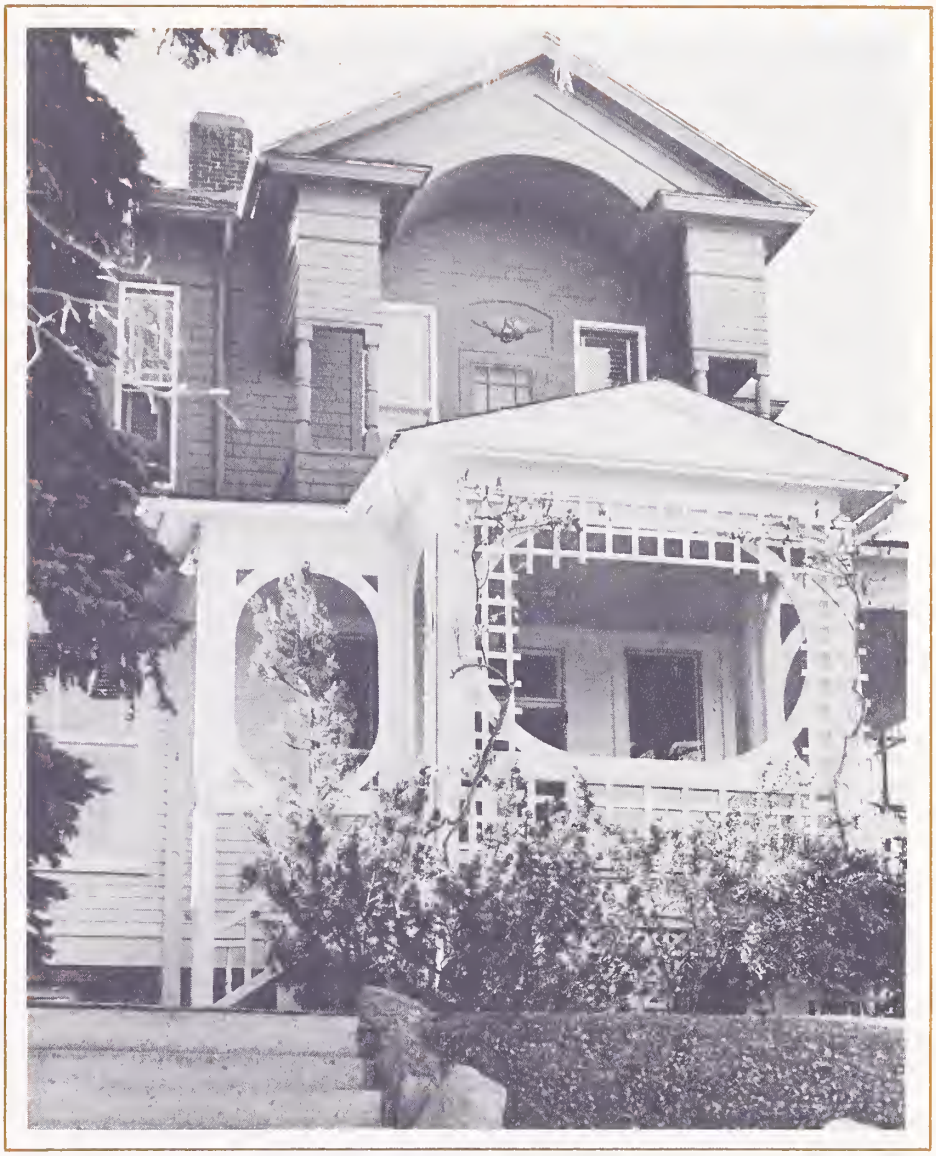
INTRODUCTION

THE MONTANA ENERGY BOOK



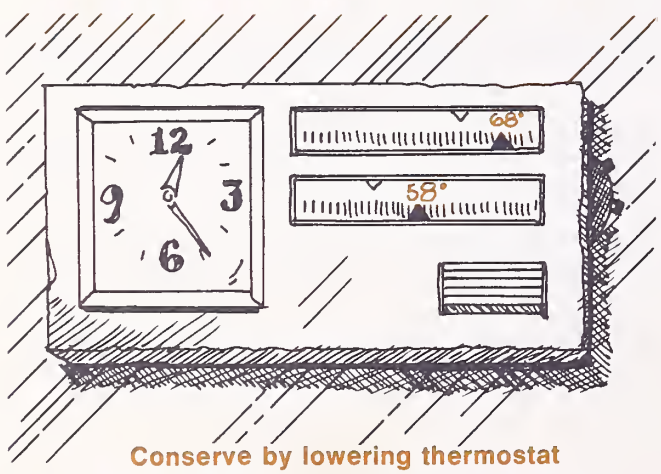
This book is designed to help you decide what conservation measures are most economical for your house. It also shows you how to make changes yourself or how to ensure that a contractor is using the

techniques that give you the greatest energy savings for your investment. One good way to begin to improve the energy efficiency of your house is to have an energy audit done. An energy audit is an examination of your house by an expert to determine how it could be made to use less energy. These audits are provided to heating customers free of charge by Montana utility companies upon request.

All the energy saving measures recommended in this book have a payback period of 7 years or less, meaning their cost would be paid back by energy savings in that time. These measures are discussed below in the order of their cost-effectiveness.

1. **Caulking and weatherstripping** are the first priorities in any weatherization program. These low-cost measures reduce bills by decreasing infiltration of outside air, add to comfort by stopping drafts, and achieve savings by allowing thermostat settings to be lowered. (See Chapter One.)

2. **You should lower daytime thermostat setting** during the winter, and set it back even more at night. Each degree of permanent setback from 72°F will result in a 3 percent fuel savings. This measure costs nothing to implement. If the setting is lowered and you feel uncomfortable, you should check for drafts and infiltration problems and have them corrected. In a well-weatherized house, you should be comfortable in winter at settings of 68°F during the day and at 60°F at night, and at 78°F in summer. Note: small children, older people, and those who are ill may require higher temperatures. (See Chapter Three.)



Conserve by lowering thermostat

3. Your furnace should be cleaned once a year, including the duct work; filters should be replaced several times each heating season. You should **have the furnace checked** by a heating contractor every second or third year. If you have natural gas heat, be sure the pilot light is burning correctly. Qualified service personnel can adjust your furnace for maximum efficiency.

4. If you have a basement or closed crawl space, **insulate the rim joist.** Placing insulation on the outside wall where the foundation joins the frame of the house and the floor joists meet the rim joist will reduce heat loss significantly. Also, caulk the cracks along the sill plate (the wood placed directly on top of the foundation). (See Chapter Two.)

5. To prevent heat loss, **weatherstrip entrances to unheated basements and attics,** and all doors leading from heated spaces to unheated spaces. (See Chapter One.)

6. **Insulate attics, walls, ceilings, floors, and crawl spaces** to at least the minimum R-value suitable for Montana's climate. (See Chapter Two.)

7. **Install plastic, wood, or aluminum storm windows** to reduce drafts and heat loss through glass. (See Chapter Two.)

8. DNRC does not recommend insulating the exterior walls of existing houses, except possibly in extreme cases where there's little or no insulation at present. The process of installing the insulation (usually requiring many perforations of the wall) often costs more than it's worth. Therefore, wall insulation, if installed at all, should be the last step in making an existing house energy efficient.

There are other measures that can save energy and money and make your home more comfortable. These are discussed in this book, with the most cost-effective discussed first, on down through other measures that may cost more or be less effective. The table of contents can help you locate topics of special concern to you. Better yet, invest some time reading all the chapters. This information can help you combat energy costs.

Keep several points in mind as you begin to increase the energy efficiency of your home. Heat travels into and out of your house in two major ways: by infiltration (leaks through cracks); and by conduction (heat transfer through materials of which the house is constructed). Both these sources of heat loss can be remedied by weatherizing the house and improving the efficiency of your heating and cooling systems. Improvements to an existing house are called "retrofits." First you should reduce infiltration by controlling or plugging leaks that allow heat to escape from your house. These are the least expensive measures. After plugging leaks you should consider increasing the efficiency of your heating and cooling systems and insulating your building to further reduce heat loss.

This book does not provide savings estimates for each conservation measure. Exactly how much you save in your particular house from an action or combination of actions depends on many variables that are difficult to calculate. Variables include future weather conditions, your particular living patterns, the order in which conservation actions are taken, the current condition of your home and heating system, and the cost of a loan if you borrow for your conservation improvements. Estimates of savings achieved through improved heating system efficiency and thermostat setback are presented in Chapter Two.

Another variable is the cost of conservation measures. Consumers generally overestimate the costs involved in weatherizing or improving heating system efficiency. Conservation measures aren't always expensive—in fact, many of the most effective cost nothing or can be done for less than $100 (for example, caulking, weatherstripping, furnace efficiency testing, lowering the thermostat, and insulating rim joists). For other measures, you should take the time to shop around and compare prices. You may be surprised at the range of prices. Don't make a large investment before investigating less expensive measures. You can do many of the most effective measures yourself. However, if you do decide to hire a contractor, consult at least three and compare estimates. Be wary of savings claims made in product advertisements.

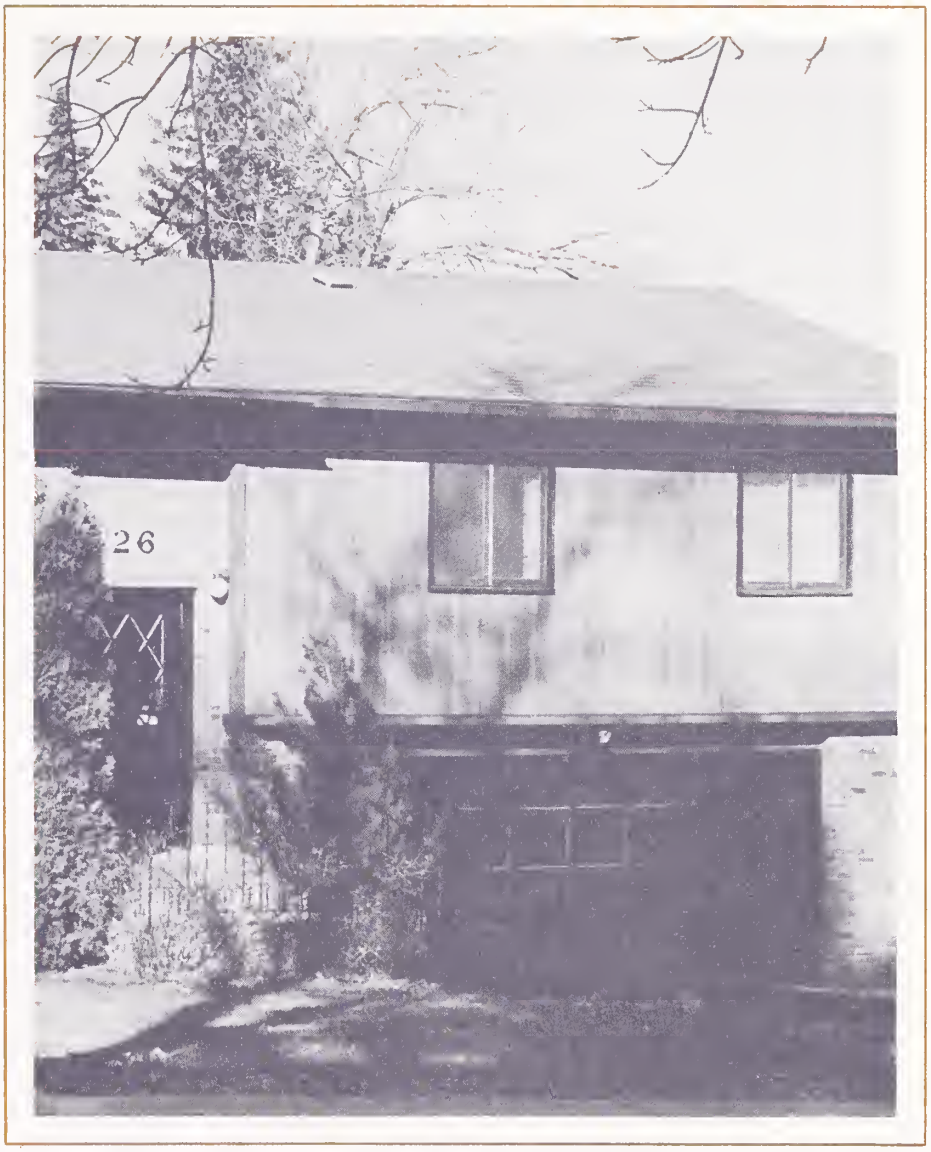
To check your progress or success after taking conservation actions, compare your energy *consumption* year after year—*not the amount you pay for it.* Since energy prices fluctuate, comparing how much money you spend on energy every year may not accurately reflect reduced energy consumption. Colder weather, your individual living patterns, or the number and age of people living in the house can make a dramatic difference in your utility bills.

Retrofits can reduce consumption by up to 50 percent, often lowering bills suddenly. However, if energy prices rise, bills may not go down as much as expected. Remember that the increase is less rapid than it would have been had you not retrofitted, so you nevertheless save money.

Investments that increase the energy efficiency of your dwelling have both immediate and long-term effects. The conservation measures listed in this book can immediately make you more comfortable, and within 7 years they will probably save enough in decreased energy costs to pay for themselves. Even after your investment is recovered, you'll continue to save every year during the life of the retrofit.

CHAPTER ONE

INFILTRATION: COLD DRAFTS AND COSTLY LEAKS



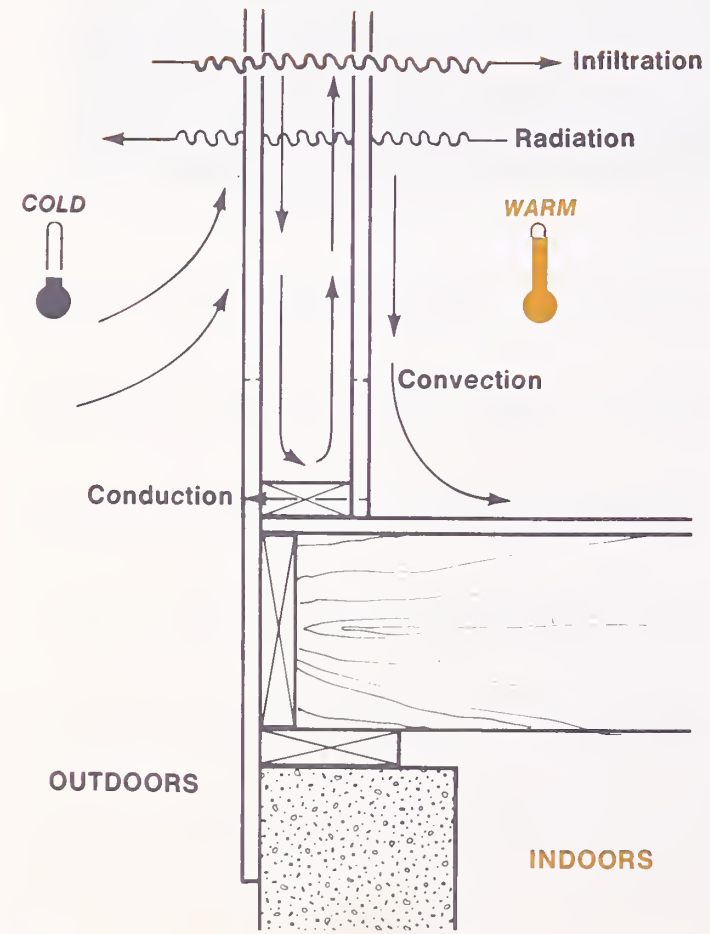
In many parts of Montana the wind blows much of the year, and in cold weather, cold air forces its way into houses and pushes out warm air. Natural convection also works to move warm air upward in a house, and

much of it escapes through cracks and other openings. Warm air tends to move to cooler spaces, and the effect of warm air rising and being replaced by colder air can reduce temperatures in living areas by several degrees.

In a home with 12 3-foot-by-5-foot windows, each having a crack of just 1/16 inch along the perimeter, the total air leaking is equivalent to the loss through a hole the size of 12 bricks. That kind of leakage will negate the effectiveness of insulation. If you seal all cracks with caulking and weatherstripping, the comfort and energy efficiency of your home can be increased. Therefore, it is important to caulk and weatherstrip doors, windows, and building joints.

You and your family may feel uncomfortable, or even have health problems in a chilly, drafty house that's hard to keep warm. If you feel cold air or drafts, you may raise your thermostat setting, but you still have the drafts, and your fuel bills rise with the thermostat setting.

House Heat Loss by Infiltration, Conduction, Convection and Radiation



Infiltration affects your fuel bills in another way. Your heating or cooling system keeps you comfortable by heating or cooling the volume of air in your house. Every house needs ventilation for health and comfort reasons, and ideally, the air in the house should escape and be replaced 1 to 1½ times per hour. These needs may vary somewhat depending on circumstances such as whether someone smokes or animals are kept inside. At any rate, your heating system must, at minimum, reheat a new volume of air every hour. Heating this air raises your fuel bill, as does replacing heat that escapes by conduction through walls, floors, and attics. The efficiency of your heating system in converting fuel to heat also affects your bill. Most houses have enough leaks to provide 2 or 3 and sometimes even more air changes. If your furnace heats 2, 3, or 4 changes of air every hour instead of 1 or less, it is obviously burning much more fuel; infiltration can account for 1/3 to 1/2 of the fuel bill.

Don't be misled into thinking that only very old, dilapidated houses have high infiltration rates. Infiltration paths often are unseen and exist in all houses by the very nature of the way they are built. Buildings have joints and places where different materials meet. They also have openings for wires, pipes, and electrical outlets, and cracks around windows and doors. All houses settle over time and building materials separate to some extent and leave cracks.

Fortunately, infiltration is one of the cheapest and easiest avenues of heat loss to correct. You can do most of the work yourself. It requires an inspection of your home, some inexpensive materials, and some time. The effort usually is well worth it, and your financial savings can be significant. You will also feel more comfortable inside your home.

Remember, too, that although we're discussing winter conditions, the same situation occurs in summer. The only difference is that warm air enters your home and cool air escapes. Your air conditioner must work overtime to cool and dehumidify large amounts of air.

Infiltration problems should be dealt with before you consider insulating your home. Insulation will never have a chance to save you energy and money if leaks are stealing the heat.

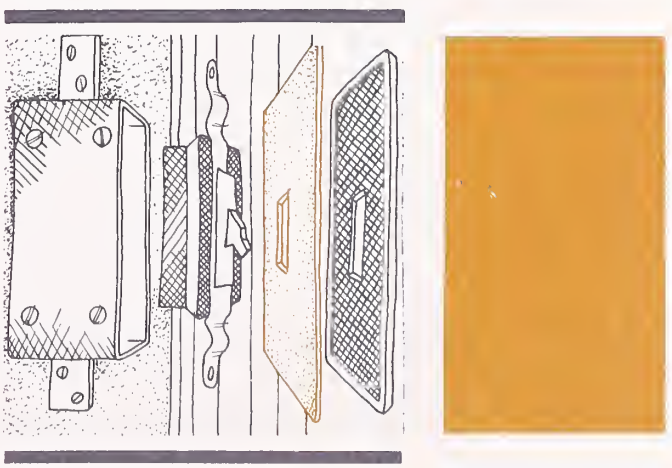
PLACES TO LOOK AND THINGS TO DO TO COMBAT INFILTRATION

Cracks around windows and doors allow drafts. Even though many cracks are small, the heat your house loses can be substantial. The cracks around doors and windows can steal as much heat as a hole in a wall. Even greater infiltration occurs in other places.

The following is a checklist of the major paths of infiltration and suggestions on how to correct them. These measures are described in more detail later in this chapter.

1. Places to caulk
   - — Cracks around window and door frames
   - — Wherever two building materials join (for example, where brick meets stucco or wood)
   - — Split or broken siding
   - — Where pipes, wires or water faucets enter the house
   - — Where siding and the sill plate meet the foundation
   - — Mail chutes
   - — Mortar joints
   - — Cracks in the foundation
   - — Between window and door drip caps and siding
   - — Where storm windows meet window frames (do not caulk the bottom of the storm window, however, because moisture must have a way to escape)
   - — At corners formed by siding
   - — Between porches and the main body of the house
   - — Where fireplaces or chimneys penetrate the frame of the house
   - — Joints where trim meets siding
   - — Under door thresholds
   - — Cracks between door jambs and door stops
   - — Where pipes under sinks penetrate the floor
   - — Window stops
   - — Around exterior basement doors and cracks in attached garage doors
   - — Fan installations in kitchen or bathroom.
2. Places to weatherstrip
   - — Sliding glass doors.
   - — All windows and doors, especially around door thresholds. Don't neglect basement windows and access doors to unheated basements or attics. Also, don't forget doors of attached garages that provide a buffer between the outside and your house interior.
3. Recondition windows or rehang doors that are in poor shape, or replace them.
4. Replace cracked or broken window panes and repair old, cracking putty.
5. Use exhaust fans, such as range hood fans or bathroom fans, sparingly; they can empty a house full of heated air in a surprisingly short time. Be sure that they are sealed tightly when not in use so there is no way for heat to leak out.

6. Insulate electric outlets and light switches on exterior walls or interior walls that are near exterior walls; much air escapes around them. There are inexpensive packages of foam backing that can be placed just behind the outlet plate. Notice also door locks that are unused; seal the holes with tape.



7. **Install storm windows** and caulk them properly.

8. **Aluminum siding helps** lower infiltration, but it does not insulate unless there is insulation added to the back of the siding. Beware of excessive claims—investigate before you buy siding.

9. **Inspect basements and attics** carefully. (See the section on attic bypasses in Chapter Two.)

10. **Don't open windows and doors unnecessarily.**

11. **Consider landscaping** to aid in controlling infiltration. (See Chapter Eight.)

12. **Check for cracks** between your baseboard and floor and between your ceiling perimeters and the attic.

13. **Use fireplaces wisely;** they are a major cause of infiltration. If you have fireplaces, read the section on them at the end of this chapter.

14. **Consider using movable window insulation** or insulated draperies that seal tightly on the sides and bottom of large windows or sliding glass doors. Conventional draperies, or even draperies with insulation, lose much of their insulation value if they aren't tightly sealed to prevent cold air from leaking under the drapery. Also, make sure that draperies don't cover heating panels or ducts under windows.

15. **Insulate the rim joist** in basements or closed crawl spaces. (See Chapter Two.)

16. **Remove window air conditioners** in the winter or cover them carefully. If there are air conditioner sleeves, insert a piece of insulation in the front when the air conditioner is removed.

CAULKING

Caulking should be applied wherever two different parts of your house meet (for example, a porch and a wall), wherever different materials join, and wherever there are cracks and holes. Because houses are made from many different materials, they naturally have many small joints and cracks throughout. As a house settles and expands and contracts with temperature changes, these cracks and joints will change in shape and size and new ones will appear. Also, there are many openings where pipes, wires, and faucets enter a house. Keep these areas in mind and follow the checklist above to inspect your house. Even if your house has been caulked, you must reinspect it periodically, since caulking does wear out and loses its effectiveness—how long it lasts depends on the type of caulk used and the conditions to which your house is exposed.

Types of Caulking Compound

To determine how much caulk you need, remember that a tube of caulking compound (11 ounces) will draw a ¼-inch bead about 25 feet long. These tubes, which fit into caulking guns for application, can be used in most areas. For gaps over ¼-inch wide, you must first use oakum, caulking cotton, sponge rubber, fiberglass, or some other filler before applying caulking.

In choosing caulking, be careful to select types that will work where you want them. Different types have different characteristics, different life spans, and prices. Some are easier to apply than others. The following is a description of common types of caulking compounds and their characteristics. Be sure to read instructions printed on the tubes before purchasing them.

ACRYLIC LATEX OR LATEX

This can be used where wood meets brick or cement and to fill cracks between walls, woodwork, baseboards, and doors. Do not use acrylic latex or latex on fresh wood or new siding; use it only on narrow cracks because it will shrink. It is good for exterior use, but the caulked areas must be painted. Some compounds are better suited for interior use. Check the label. It is fairly easy to apply, and it can be applied in cool or damp weather as long as the temperature is above 40°F. It lasts from 6 to 20 years and costs $1.00 to $2.00 per tube. These 1985 prices will

change. Prices are estimated for all types of caulking to give you an idea of relative prices.

BUTYL RUBBER

Butyl stays flexible, adheres to almost any surface, but is slightly more difficult to apply. It is especially good to use on metal-to-masonry joints, and on tile or glass. It can be used around windows, doors, sinks, tubs, and chimneys because it has a high moisture resistance. It should not be applied in temperatures above 85°F but is good for exterior use because it remains flexible, may be painted over after 7 days, and lasts 15 to 18 years. Current price is $1.75 to $3.00 a tube.

OIL OR RESIN-BASED CAULK

This hardens quickly and will not do well where flexible materials are needed, as on a crack that will expand and contract. It is not long-lasting, may dry and crack, and can stain unprimed surfaces. It costs $1.79 to $2.00 a tube.

POLYSULFIDE

It sets instantly and is highly moisture-resistant. This caulking can last 20 years. It adheres to primers recommended by the manufacturers. Although nontoxic, it may irritate the skin. It costs from $4.00 to $6.00 a tube.

POLYURETHANE

It adheres well, does not need a primer, and can be painted. It can last 20 years. It may contain toluene diisocyanate, an irritant and sensitizer, so avoid inhaling fumes and avoid skin contact. It is priced about the same as polysulfide.

POLYVINYL

This caulking bonds well, lasts up to 10 years, but loses its flexibility when it dries. It costs about $2.00 to $3.00 a tube.

SILICONE

Silicone can be used on any surface and bonds well. It has a high resistance to moisture, and is especially good for showers, tubs, plastic, metal and ceramic tile surfaces, gutters, and downspouts. It lasts over 20 years and is available in clear, white, aluminum and bronze colors. However, most kinds of silicone caulking cannot be painted, and there are problems with the kinds that are paintable. It costs $4.00 to $7.00 a tube, and may be found on sale for substantially less. Uncured silicone may contain xylene, a flammable substance that may also irritate the skin.

FOAM

Expanding foam is ideal to fill and seal large openings that caulking compounds cannot fill. The foam, which looks like thick shaving cream, is dispensed from a can under pressure through a small plastic hose that the user directs into gaps, cracks, or other openings in the exterior shell of a home. Cost is $3.00 to $7.00 for an 8-ounce can.

Often made of nontoxic urethane, the frothy foam expands and cures to a closed cell foam that fills cracks and holes around windows, doors, wall outlets, base plates, plumbing, and electrical openings.

Foam is useful because it can expand into uneven or inaccessible areas, bond to different surfaces and seal in place. Nontoxic urethane foam does not shrink, dry out, or become brittle with age. This is what makes it effective in stopping air infiltration.

OTHER

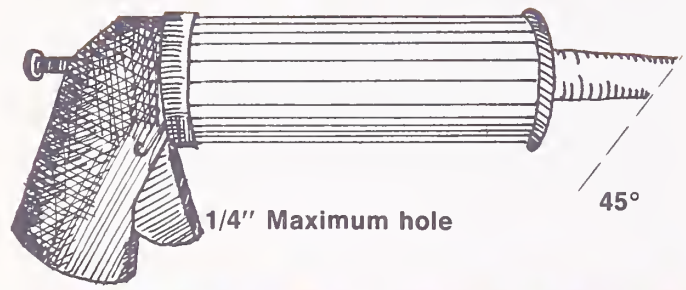
Special masonry patching materials are available as caulking for foundations, stucco and cellar door and window frames. Most other sealants will not stick to masonry or concrete. Special caulk called fireplace or boiler caulk is available for use near heat sources.

How to Caulk

You will need a caulking gun, a tube of caulking compound, a piece of coat hanger wire or a nail, a utility knife, and a putty knife. You may also need a brush and scraper, a ladder, filler, and a solvent (paint thinner for butyl or water for latex), and a big wood screw to plug the spout if you have a partially used tube when you finish. Choose a relatively warm and dry day to caulk. Here's what to do:

1. Clean the surface to be caulked with a scraper and brush. Caulking will not adhere well if the surface is dirty, dusty, or has peeling paint. Remove any tar or old caulk. Some surfaces may need to be wiped with a solvent.

2. Select the appropriate caulking compound and cut the nozzle of the tube at a 45 degree angle at a width of ¼-inch. Puncture the interior membrane of the tube with a coat hanger wire or nail. If you forget this step, you may rupture the tube when you press the trigger of the caulking gun.



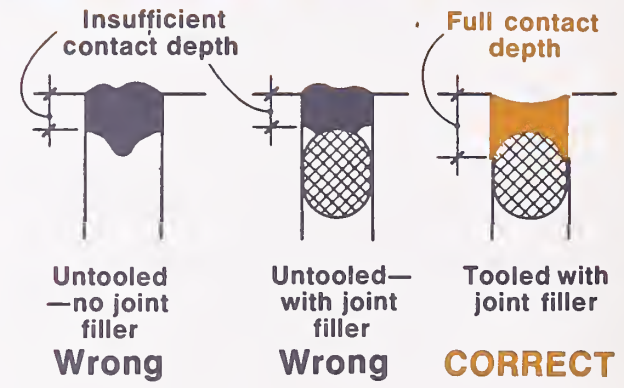
3. Place the tube in the gun, bottom first, and insert the plunger. As you squeeze the trigger, the caulk will flow rapidly, so be prepared. When you release the trigger, caulk will continue to flow for a short while.

4. To fill a crack, PUSH the gun along the crack with the angled nozzle running fairly flat along the surface. Do not let the bead get bigger than the nozzle tip. Just push slowly and steadily. On vertical cracks, start at the bottom and push the gun upwards. Apply slight pressure as you move the gun upwards. You can remove the excess with the solvent and a rag. Stop the flow by releasing the trigger. Twist the gun slightly as you disengage. The aim is to seal between two surfaces of the crack—not necessarily to fill the crack completely.

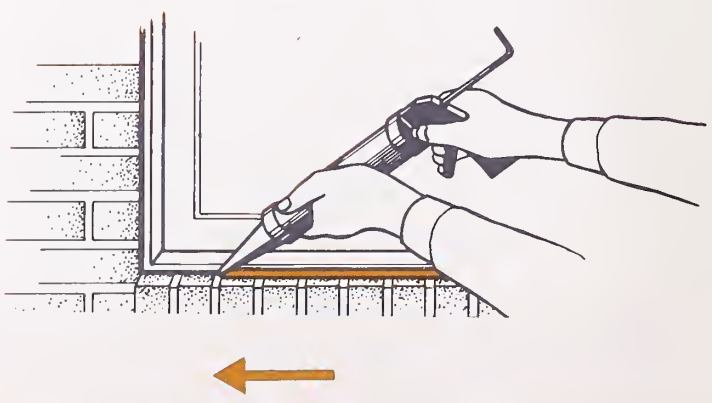
5. If the crack is very deep or wider than ¼-inch, use scrap insulation or filler to stuff the crack before you caulk.

6. When you finish, seal the caulking tube by inserting a screw and twisting it tightly.

Remember NOT to caulk the louvered openings of eave or soffit vents since your attic must be ventilated. Very large foundation cracks may have to be filled with mortar; serious problems may require repair by a mason.



Push Method of Caulking



WEATHERSTRIPPING

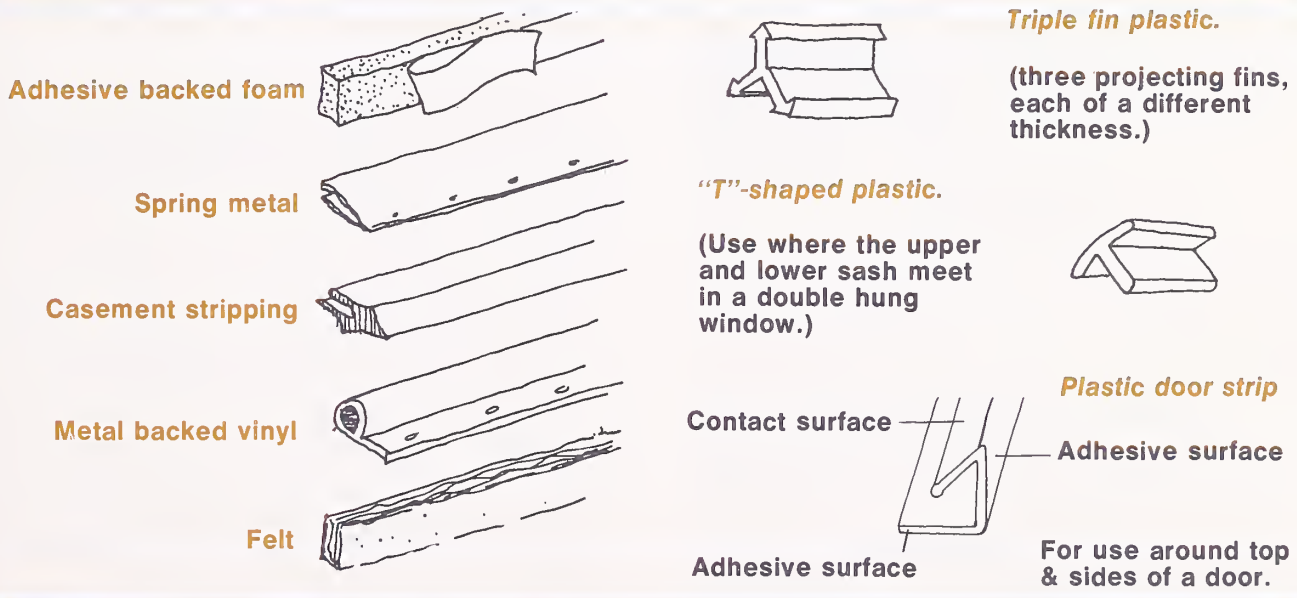
Weatherstripping is often advocated for stopping leaks and drafts around windows and doors. Most types of weatherstripping are durable, inexpensive and easy to install, but other approaches to stopping leaks may be better. For example, for doors that have gaps, and windows and doors without tight fits the best option is to rehang the doors and recondition the windows to get a tight fit.

Look for gaps, especially around the bottom and top of doors and around window sashes. Hold a tissue or feather around frames to test for drafts. Windows that rattle when tapped are a sure sign of leaks. Check all your windows. Don't forget to test doors and windows in attached garages, basements, and attics.

Weatherstripping is available in many varieties, forms and materials. Types vary greatly in durability, costs and ease of application. In general, felt and foam types are not especially durable, may require reapplication every year, and will deteriorate and possibly cause wood damage when wet. Metal strips will work, but are difficult to install, as are most vinyl strips, and they may crack over time. However, some new vinyl strips are fairly easy to install. Rope caulk is also available; it is inexpensive and can be used on doors or windows you do not intend to open in the winter; it can easily be removed in the summer.

Another type of weatherstripping is rubberized tubular gasketing. It comes either alone or attached to wood strips. The darker the color, the higher the rubber content and the more durable the product.

When you buy weatherstripping, check the instructions to determine how difficult it will be to apply and where you can use it. You might also consult *Consumer Reports*, which objectively rates many products.

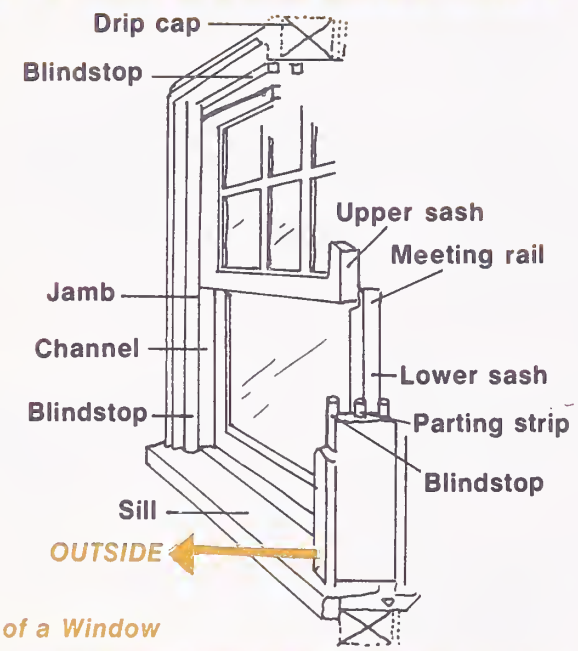


WINDOWS AND DOORS

Windows and doors often present special problems. Although they may not be the major contributors to drafts and discomfort in your house, they are obvious sources and are easy to locate. If you enjoy do-it-yourself projects, a lot can be done to correct window and door problems. In many cases, reconditioning windows or doors may be less expensive than investing in replacement units.

Windows

There are two classes of windows: primary and secondary. A primary, or prime, window is the window originally installed when the house was built. It may be double-hung, casement, aluminum awning, or some other type. Secondary windows are "extra" windows added to the primary windows for additional insulation and draft protection. These are referred to as "storm" windows. They can be mounted inside or outside the primary window. "Replacement" windows are new primary units. Primary windows should be as draft-proof as possible.



Parts of a Window

PRIMARY WINDOWS CONVENTIONAL DOUBLE-HUNG

Most windows are the double-hung type. The illustration shows how they work. The upper sash is held in place by the exterior bead and the parting strip. These guide the sash up and down and fit tightly against it to stop drafts. The sash is held up by a counterweight attached to the upper sash by a chain or cord. Pulleys enable the chain to roll smoothly. The weights hang inside the wall behind the casings. Access to them is achieved through the weight box covers. The lower sash is held in place by the parting strip and the interior window stops; it has the same counterweight arrangement. Stops are nailed in place.

The parting strip is mounted into a long channel cut into the frame. It should fit snugly. Also, check the matched bevels on the sashes where they meet in the middle of the window. The sash lock pulls these bevels together to stop drafts.

PROBLEMS AND SOLUTIONS

A few tools are necessary to fix window problems. If you proceed carefully, each window can be made almost new. This is much less costly than buying replacement windows. You may need the following: a putty knife, a screwdriver, a small hammer, a ¾-inch chisel, a tape measure or ruler, a miter saw and box, a nail set, 4-penny or 6-penny finishing nails, sash chain and clips, putty, caulking, a wood rasp, a utility knife, small pry bar, a wire brush, boiled linseed oil, clear wood sealer, push points, wood putty, a caulking gun, and safety glasses, You may also require replacement sashes, parting strip, window strip, flat "L" brackets, sash locks and wood glue.

Most serious window problems require taking the window apart. Here are simple instructions for disassembling a wooden double-hung window.

1. With a utility knife, cut through all paint-sealed joints on the front and back of the window stops, parting strips, and sashes.

2. Locate the nails in the stops. Use a small hammer and nail set and drive the nails through the stops until you can remove the stops completely. The header stop can remain in place.

3. Carefully pull the lower sash toward you. Unhook any ropes or chains and set the sash aside.

4. Lower the upper sash completely. With a chisel or small pry bar, begin prying the parting strips out, from the top down. Remove both strips completely. Note: These are very brittle and may break. It is a good idea to have some replacement strip on hand. Measure the old strips and buy the size you need. It is quite

inexpensive and available from lumber suppliers and hardware stores.

5. Remove the upper sash as you did the lower sash.

6. If you need new chains, locate the weight box covers and screws that hold them in place. Insert a screwdriver in a screw, and turn it counterclockwise while tapping the screwdriver lightly with a hammer. This will break any paint seals and loosen the screw. Remove the covers and locate the weights in the wall. You may need to reattach the weights to new chains or cords. With a little practice, this procedure can be done in a few minutes.

EXCESSIVE PAINT BUILDUP

Repeated painting will change the sizes of all pieces of the window. When this happens, nothing fits tightly and cracks exist in the joints. If your sashes rattle in the frame or do not fit tightly at the top and bottom when you try to close them, you may have an excess paint problem.

TO REMOVE EXCESS PAINT

Use a paint stripper and sandpaper to remove all excess paint and smooth out all binding surfaces of the window pieces. These include sash side rail faces, flat running edge of stops, bearing surfaces of parting strips, beveled edges of sash rails, bottom of the lower sash, top of the upper sash, and the sill. You might simply replace parting strips, including the top piece, since it takes less time than cleaning them and will cost less than $1.00 per window. New stops are more expensive than parting strips, but the old ones may break when you clean them and also need replacement. Stops should be at least 1 inch wide. Strips and stops should be carefully measured and cut with a miter saw and box to keep them square.

WOOD SHRINKAGE AND DETERIORATION

Older windows that have not been properly sealed suffer from natural shrinkage of all the wood parts and damage from water and heat. Sash rails and parting strips suffer the most.

TO REMEDY SHRINKAGE AND DETERIORATION

Examine all the window pieces, especially parting strips and sashes for damage or deterioration. Replace bad parting strips. Damage to sashes may require extensive work or even replacement (sashes cost about $30 a pair). Check all sash joints for looseness. Usually wood glue will solve this problem. Flat "L" brackets can be applied to the corners to make the sash more rigid. Check joints and brackets with a framing square before mounting the screws. Badly bowed rails or rotted corner joints require that you purchase new sashes. To order these, measure the size of the window frame opening and specify the width and height when ordering. Sashes that don't fit flush with the frame can be extended by adding thin wood furring strips to the outside edges of the sash or to the top or bottom of the sashes.

FAULTY GLAZING

Putty does not last forever. It cracks, dries and falls out, leaving cracks between the glass and the wood of the sash. Tap the glass with your finger and listen for rattles. Periodically inspect the putty.

FAULTY GLAZING AND/OR BROKEN GLASS REPAIR

Small cracks in putty can be filled with fresh putty. Badly cracked and broken putty will need replacement. Broken and cracked glass also requires replacement. To remove putty and glass, always wear safety glasses or goggles. Old putty tends to be very hard and the usual method of repair is to chip it out with a chisel and clean the surface with a wire brush. Another method is to apply a water soluble paint remover to release the putty from the wood. Remember: paint removers may lead to repainting, and the chemicals are very strong and can cause burns.

No matter what method you choose, work slowly and carefully. Do not change the wood surfaces or chip them with the chisel. Beneath the putty are small metal push points that hold the glass in place. These must be removed also. Remove the glass, if there is some remaining,

and set it safely out of the way. Brush the lip and slot areas clear, coat them with a thin layer of boiled linseed oil and let it stand for several minutes.

If new glass is required, measure the opening side to side and top to bottom, then deduct ⅛-inch from each dimension. This will give you a margin of safety against irregularities when installing the glass. Lay the sash flat and apply a small amount of putty around the lip areas and into the slot. Lay the glass in place and press it very gently into the putty to form a seal. Install enough push points around the window to hold the glass securely. Then apply a generous amount of putty to the face of the glass, around the edges. Use a putty knife to form a smooth beveled edge and to make neat, angled corners. Rough surfaces and sloppy corners collect water in winter which freezes and ruins the putty. Be as neat as you can. Note: good linseed oil putty is easier to use than commercial "glazing compounds."

BROKEN OR MISSING SASH CHAINS

Weights and chains are in place to keep window sashes where you put them. In the winter they stay closed; in the summer they stay open. Missing chains can cost a lot in wasted fuel because windows will not stay closed.

TO REPLACE SASH CHAINS AND CORDS

Your windows may have ropes instead of chains to hold the weights. If possible, consider replacing them with chains for durability. Sash chains come in 40-foot and 80-foot lengths, complete with clips and hooks for attaching them to the windows and weights. To install, simply measure the height of the frame and subtract the length of the weight. Cut all four chains the same length. Install the round spring clip on one end of the chain. Feed the other end through the pulley until it hangs down into the weight box with the clip against the pulley. Fasten the chain to the weight with the hook provided and squeeze it around the chain with pliers. Replace the weights into the boxes and reinstall the covers. Be sure to check pulleys for operation and lubricate them if necessary.

BROKEN OR MISSING SASH LOCKS

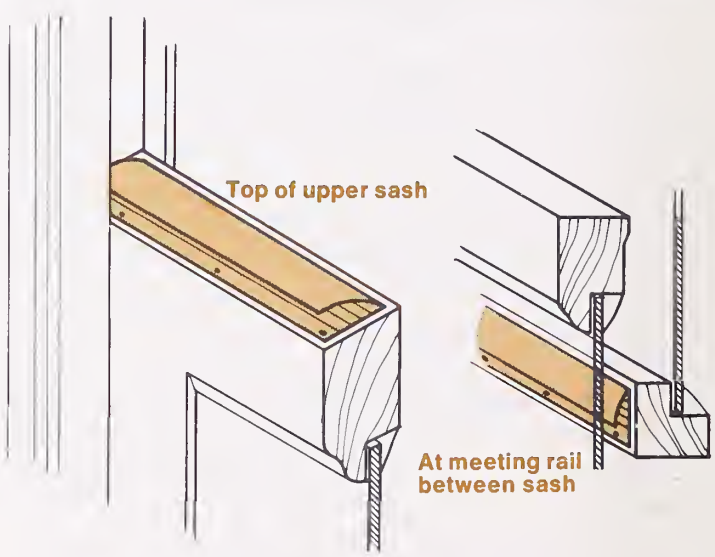
A sash lock pulls the beveled edges of the sash rails together, and forces the sashes all the way up and down. When a sash lock works correctly, it can seal the middle, top, and bottom of the window. If the lock is broken or missing, it should be replaced. Windows wider than 28 inches should have one lock at each side.

If the lock is loose, it should be tightened. If the lock pieces will not meet, be certain that all paint and dirt is cleaned away so that the sashes will go up and down as far as necessary.

To install a new sash lock, mount the catch on the upper sash first. Then mount one screw in the movable latch piece, close the lock and rotate the movable latch around until the sashes are pulled tight. Mount the last screw.

WATER DAMAGE

Check for a drip cap on the top of the exterior frame. Its purpose is to keep water from falling directly on the window.



Weatherstripping a Double-Hung Window

A badly warped or worn windowsill will keep the lower sash from sealing against it and leave large cracks at the base of the window. Replacement of the windowsills is difficult. You

may need to consult a contractor if the damage is extensive. Gaps between the inside sill and the lower sash are best corrected by adding a piece of window stop across the bottom of the sill so that it fits tightly against the lower sash when closed.

FRAMES OUT OF SQUARE

Frame openings may go out of square as the house shifts and settles. Check this with a framing square.

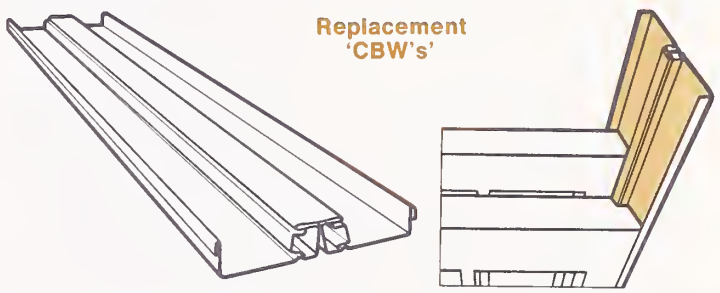
You may need to consult a contractor. A good "home owner's how-to" guide can help if you choose to do the work yourself.

WINDOW REASSEMBLY

Reassembly of the window, with new or cleaned strips, stops and chains is simply done in the reverse order in which it came apart. Any new wood you install should be thoroughly sealed or coated with linseed oil before you put the window back together. Install the upper sash with chains connected and lower it completely. Reinstall the parting strips and raise the sash to the top. Install the lower sash with chains connected and re-nail the stops. Set the stops firmly against the sash and check frequently for ease of sliding. A thick coat of pastewax on binding surfaces will help the window slide smoothly.

ALTERNATIVE REBUILDING METHODS

It is possible to eliminate parting strips, weights and chains by using mechanical metal spring pressure units of some type (CBWs). Several manufacturers supply these and most supply instructions for installation. These are a good option if the window frames are in poor condition, pulleys are missing or broken, or weights are missing.



In cases of extreme deterioration, replacement windows are required. This is usually a job for a contractor. Care should be taken in selecting replacement units as they vary in quality and type. Wooden casement windows with double glazing or thermopane are the most efficient but also the most expensive. Metal units, though inexpensive, are comparative energy wasters unless you buy those with thermal breaks (air spaces between metal components to lower heat conductivity). Vinyl insulated units are also available. Don't give up wood unless you have to.

Other Types of Windows

Be sure that joints on casement or awning type windows are kept clean, all gasketing is kept in good repair, and all operating mechanisms are lubricated.

Double sliding glass doors should be treated as sliding windows. Metal frame units should be gasketed wherever possible and covered with a storm panel during cold weather. At night they should be covered by heavy or insulated drapes with valances across the top to prevent infiltration.

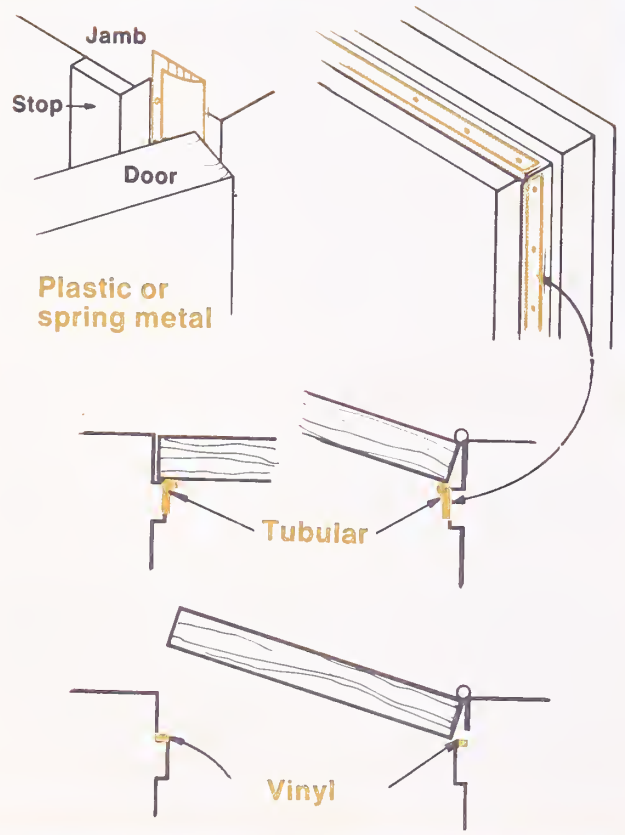
Sliding metal frame windows are very inefficient. They should have storm panels. Reglazing of such windows is usually done by removing the small rubber or vinyl gaskets and replacing the glass. If repair is too difficult, take the sashes to a qualified glazier for repair.

Doors

Exterior doors receive constant use and exposure to the weather. They can be a big source of infiltration if they do not work properly. Test all doors between heated and unheated spaces for tightness of fit. As with windows, storm doors will not solve your problems or be cost-effective without attention to primary doors first.

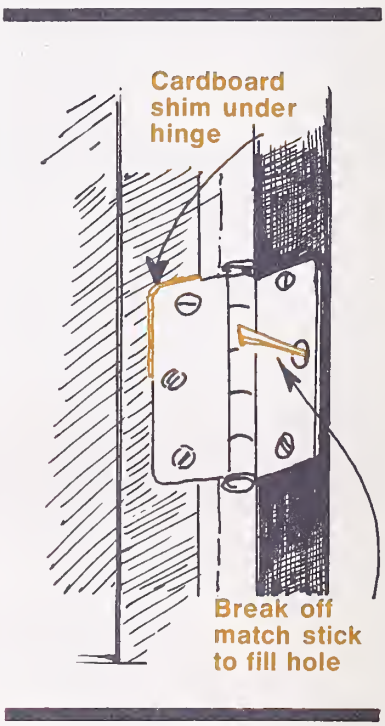
Testing a door is simple. First open and close the door from the inside. Check to see whether it drags on the floor or bumps the frame at any point. If it clears and closes smoothly, look for light around the door on both sides and the top and bottom after it is closed. Next, be sure that the door latches and that the doorknob assembly works properly. After the door is latched, it should not rattle. With the door closed, check for air spaces underneath; there should be none. If your door passes all these tests, then you need nothing else, except perhaps some heavy duty weatherstripping around the stops to ensure a good seal against heavy wind.

Weatherstripping Doors



However, the chances are that your door failed at least one of these tests. If it did, you can usually solve most of the problems quite simply, even if you are not a carpenter.

1. Loose or worn hinges. To check for this, open the door halfway and try to move the door up and down by pulling upward on the doorknobs. If the door moves, watch the hinges move and examine them for loose or missing screws, worn hinge pins, broken hinges, or nails used instead of screws to attach the hinges. If you are lucky, tightening the screws will solve your problem. If the screws will not tighten, try removing each screw, making a small wedge of wood the size of the screw hole, smearing the wedge with wood glue, and driving it into the hole. Let the glue set 30-60 minutes before replacing the screw.



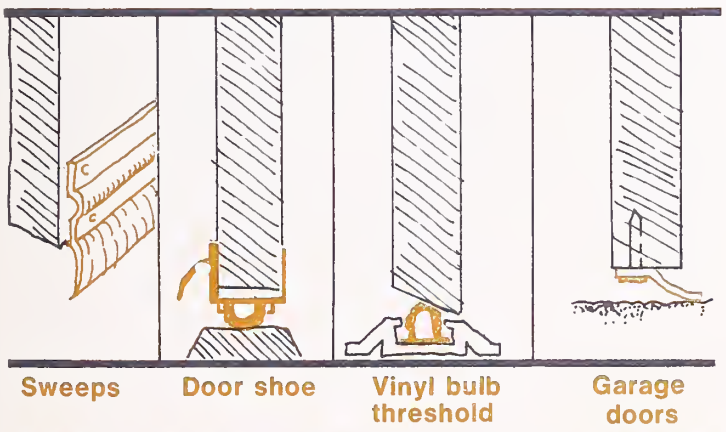
If screws are missing, be sure to use the proper size flat head wood screw—otherwise the door will not close flush. Do not use nails; they will only be pulled out within a few days and damage your door frame. If you have old, worn pins you need new hinges. These are inexpensive and can be placed directly into the old hinge openings. Be sure to buy the correct size. Most hinges are 3½-inch butt hinges,

although large, heavy doors may require 4-inch hinges. Most entrance doors are heavy and should have three hinges. Only light interior doors will work with two hinges. If your door is heavy and has only two, add a third.

If your door still drags, then rehanging or realigning may be required. If the jamb (the inside molding that meets the door) is badly deteriorated and the door itself is in poor condition, you probably should replace both. In either case, consult a contractor, since complete replacement or rehanging can be very involved.

Once the door operates smoothly, check the jamb for a uniformly tight fit at the top and sides. Use weatherstripping with plastic or spring metal, tubular, foam, or felt weatherstripping where required for a draft-free fit. (See illustration.)

Door Side Views

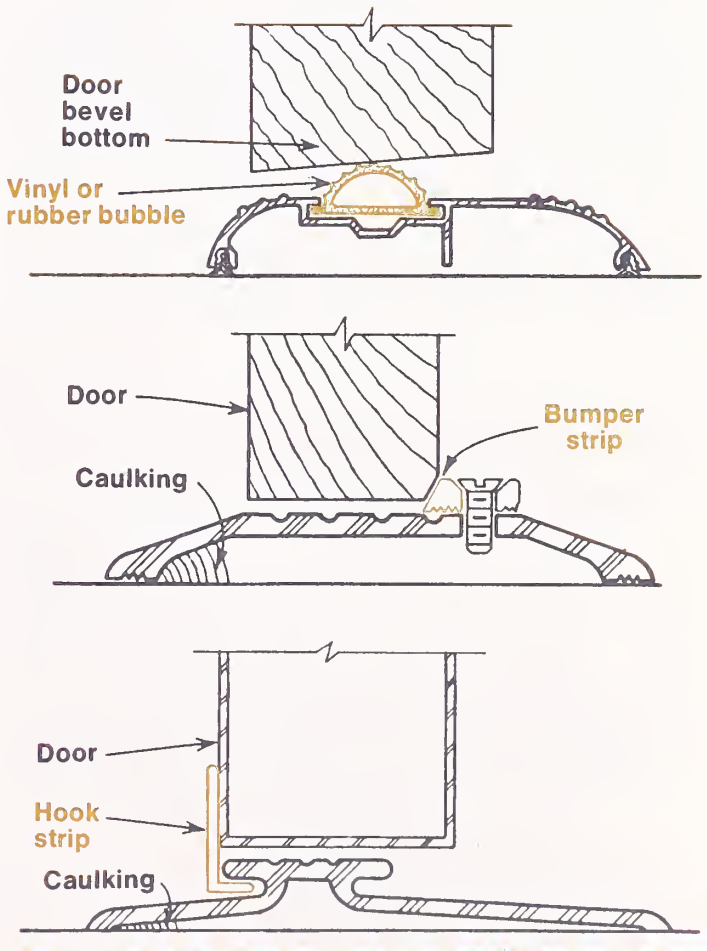


2. Door fits loosely or doesn't latch tightly. After you have made the door swing free and square, check the latch to see if it catches. Doorknob sets can cost less than $10 and are a good investment if your current one works poorly. They are packaged for sale with all necessary pieces and clear, complete instructions. Replacement of your existing set can be done in less than an hour. You will need a ¾-inch chisel, a pencil, a screwdriver, and a drill or bit and brace to drill a ⅞-inch and a ⅝-inch hole in the door.

If the door latches but rattles back and forth, check to see whether the striker plate can be set back closer to the door stop. Use a chisel to set the plate into the wood for a flush surface. You may need to plug the screw holes as with the hinges above in order for the screws to hold firmly. If the striker plate is broken, bent, or missing, replace it. If it is not possible to move the striker plate, you will have to move or replace the stops.

Stops do two things: stop the door in a fixed position and prevent drafts. They should be large and solid enough to perform both functions with ease. Most doors have stops that are too small to seal well. This would be an excellent opportunity for you to replace your small stops with heavier material with built-in gasket or weatherstripping. Properly installed, these will

Eliminating Gaps Beneath Exterior Doors



greatly reduce the possibility of drafts around your door. They are available in sets and vary in quality. Gasketing alone is also available in rolls and can be mounted behind existing stops.

To remove the stops for resetting against the door, drive the existing nails through the stop with a nail set until the stops come free from the jamb. Smooth the edges of the stops and renail them in new positions with 4-penny or 6-penny nails (or install new stops the same way). Nail the latch side first, then the top, and finally the hinge side, checking frequently to ensure a tight fit with no binding or pinching. Caulk the front edge of the stop when you are finished to seal the joint.

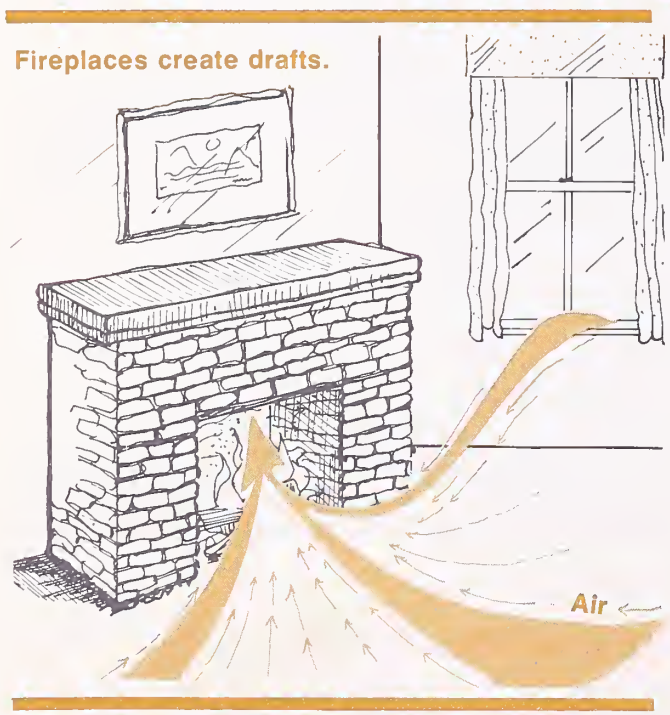
3. Gaps. If you have space beneath your door, it can be eliminated with commercial products and a screwdriver. If the space is only a small crack, buy and install a door sweep on the door bottom. Cut it to the proper length to match the width of the door with some of the flexible material left protruding from either end of the metal. Screw the piece onto the bottom of the door, low enough for the material to ride along the floor and seal the crack when the door closes.

If the space under the door is ½ inch or more, you will need some type of threshold that will build up the doorsill to meet the bottom of the door when it is closed. There are several types on the market. The simplest is an oak threshold that can fill a gap of 1 inch or so, but it requires considerable skill to fit it to the door. More common varieties are aluminum with rubber or vinyl "bubbles" on the top that seal drafts as the door touches them. Usually the door must be cut off at the bottom to fit the threshold. The easiest to install is a bumper-type aluminum saddle. The most effective is a two-piece, adjustable, interlocking type. Many come with diagrams, some with instructions. Most, like door sweeps, only require common sense for installation.

METAL DOORS

If you have common, uninsulated steel doors and/or frames, most of the above instructions will not work. Modifications are difficult and the benefits are questionable. You might consider replacing such doors with wooden doors and frames. Consult a qualified contractor or carpenter. Try not to replace wooden doors with uninsulated metal ones because wood is a better insulator than metal. If you do buy metal doors or windows, purchase those with thermal breaks that provide more insulating value. Superinsulated steel doors are available at most hardware stores and large lumber yards, and are the most energy-efficient doors you can get. Dealers have brochures on these.

Fireplaces



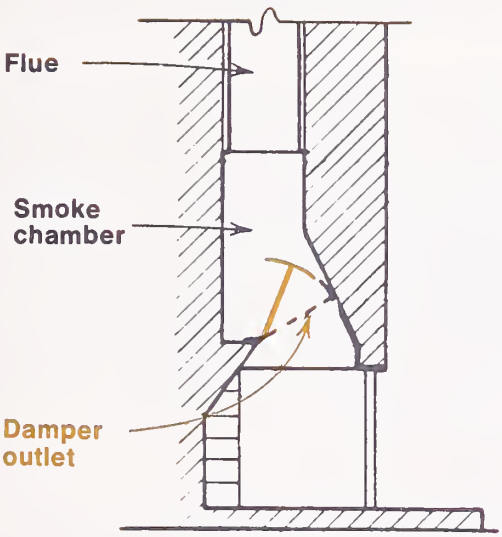
Fireplaces create drafts.

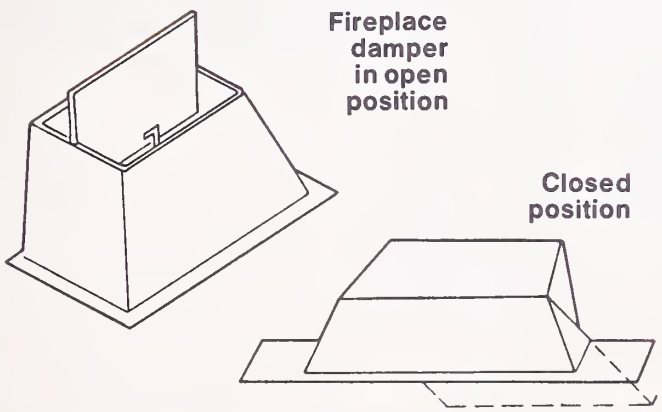
Romantic traditions of relying on fireplaces for heating and cooking, along with the mystery and attraction of a crackling fire, make many people want fireplaces, even though they can cause major heat loss if not used properly. It is important to remember a few tips on how to use a fireplace without adding to energy bills.

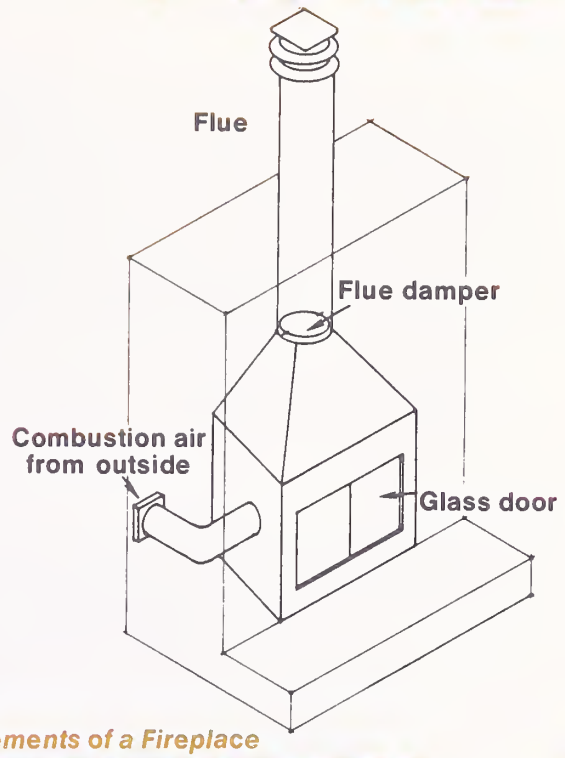
MAKING YOUR FIREPLACE WORK FOR YOU

1. Dampers. If you don't have a damper, have one installed. If it is broken or does not close tightly, have it repaired or replaced. Even a closed damper does not completely stop air movement up or down the flue. Dampers warp and rust over time. They also allow conductive heat loss, since they are made of only a thin

layer of metal. On a sunny day when you have no fire, check the damper with a mirror to see whether light comes through it. New dampers cost from $30 to $125. If you do not use your fireplace, seal the damper with fiberglass insulation stuffed in the chimney and some type of gasketing placed around the damper.







Basic Elements of a Fireplace

2. Use on Cool Days Only. Use the fireplace in mild weather rather than during cold or windy weather. In severely cold weather, chimney draft is especially strong and room air is drawn out at a faster rate. Set the thermostat back while the fire is burning, regardless. Close off the room with the fireplace and open the window a crack to provide combustion air, if you don't have a combustion air supply near your hearth.

3. Glass Screens. To control the amount of heated inside air going up the chimney, consider installing a glass door or screen in front of the fireplace. Glass screens allow radiant heat into the room, but help regulate the amount of air drawn into the fireplace. They reduce heat loss, particularly when the fire is low and the damper cannot be closed yet. Be certain to buy the kind of doors with vents that allow the doors to be kept closed the entire time the fire is burning. If you do open the doors while the fire is burning, close them when the fire dies down, but before you close the damper. Though effective, these doors can be quite expensive, up to several hundred dollars, depending on size.

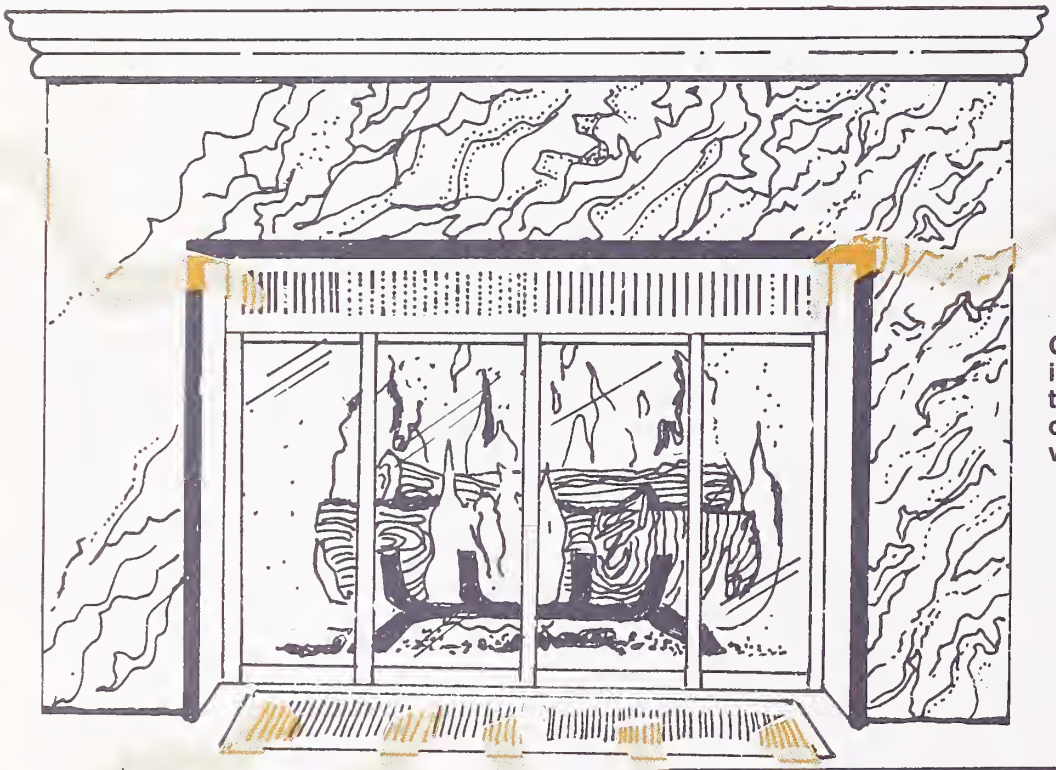
4. Tubular Grates. Fireplace efficiency can be almost doubled with the use of tubular grates. These grates use convection or forced air to move heat into the room. Those that use electric fans to move air are more efficient than those without fans. The thick-walled pipe should be inspected periodically for holes that may develop. Although these units do increase heat output considerably, many are quite expensive. Do-it-yourselfers may want to design and build their own from steel pipe or tubing. Small blower motors can be obtained from electric motor distributors.

5. Metal Fireplace Inserts. Some manufacturers are now producing stove-like double wall inserts that can be installed in existing fireplaces. These are equipped with tight-fitting glass or metal doors, a vent that pulls combustion air in from outside, and built-in fans. These inserts can raise the efficiency of your

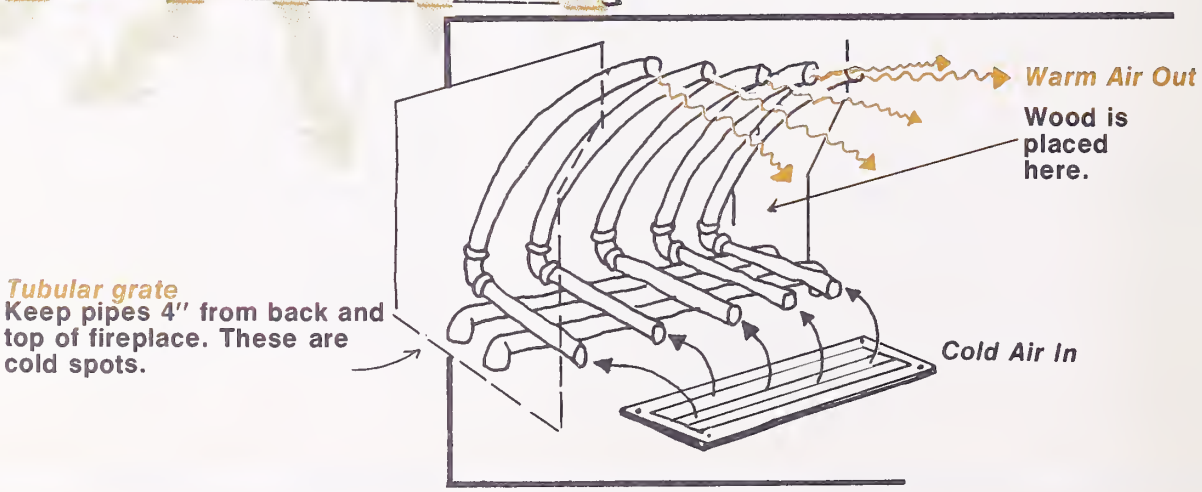
fireplace and are useful if you use your fireplace a great deal.

6. Fresh Air Supply Source. In combination with glass screens or as an alternative, you can install a fresh air supply source directly from the outside to the hearth of the fireplace. This can be done by using a 4-inch dryer vent pipe and an adjustable floor vent register mounted in front of the firebox. Talk to a reputable stove dealer for more information about supplying fresh air to your fireplace.

7. Heat Circulators. You may also choose to install one of the many available air and heat-circulating fireplace liners. This option is particularly advantageous if your fireplace is on an exterior wall and losing valuable heat to the outside, though it does not eliminate the need for a direct fresh air supply.



Glass screens radiate heat into the room, but regulate the amount of air drawn *out* of the room into the small vents of the fireplace.



Wood-Burning Stoves

There's no way to know exactly how many wood stoves are now in Montana homes, but stove suppliers in the forested areas of the state say that 15,000 were sold in the peak sale years of 1979 to 1983. Wood is getting harder to obtain in some areas, so people want stoves that use less fuel to produce the desired amount of heat.

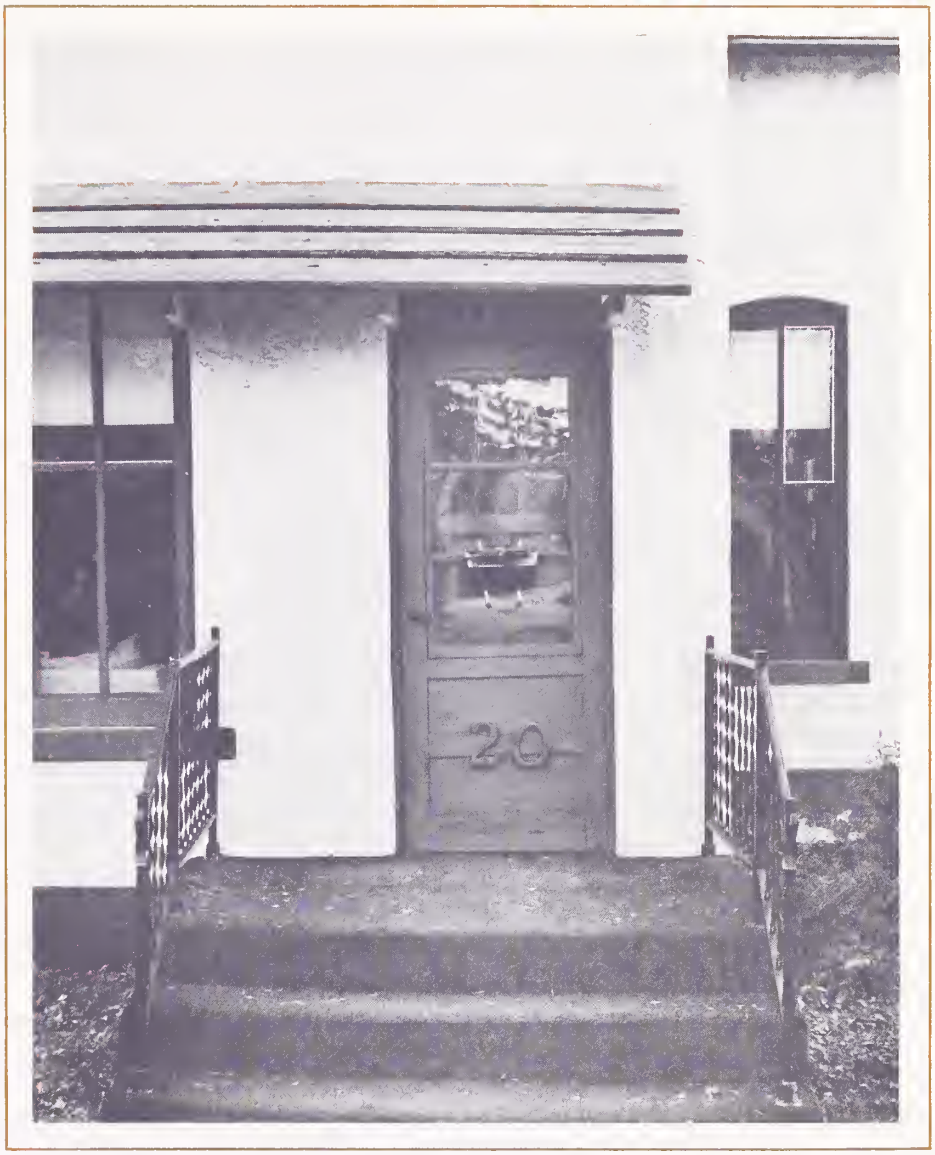
A Helena stove dealer says customers are concerned with good neighborhood relations and want stoves that will produce less smoke. By 1987, all new stoves will have to meet strict new federal standards for emissions and efficiency. Montana offers a 10 percent tax credit on new wood-burning stoves that meet certain emissions standards. Newer homes with tight construction make interior air quality an important issue, too.

DNRC has a publication available that describes different types of wood stoves, their special features, and what they cost to buy and maintain. Installation methods are explained in detail. Antipollution devices such as catalytic converters are described. Readers are also advised on how to obtain permits to cut wood, best varieties to cut, safety measures in the forest, and how to store their wood supply. You can request this publication, entitled "Wood Heat," by writing to DNRC or calling (406) 444-6696.

Advances in stove design may make them an efficient, cost-effective, and attractive way to supply all or part of the heat for many homes in Montana. In many cases, however, home owners may be better off using fuel other than wood.

CHAPTER TWO

INSULATION: YOUR HOME'S THERMAL BLANKET



After you have dealt with infiltration problems, your next step is to wrap the heated areas of your home with insulation to lower the amount of heat you lose through the walls, floors, ceiling, and glass sections.

Insulating materials do not heat or cool, but prevent the flow of heat into or out of your house.

Two points are important in determining how much insulation is enough: how much insulation you have now, and what degree of thermal efficiency you want to achieve.

If you don't know how much insulation you have, look for labels on your existing insulation. If no labels are present, measure the depth of the insulation and refer to the chart on page 25 to determine the R-value.

R-value, the resistance of material to the passage of heat, is the measure used for comparing thermal efficiencies of different types of insulation. Two different insulating products with the same R-value will provide the same insulating value, despite their different thicknesses, characteristics, or prices. The higher the R-value, the greater the heat resistance and the better the insulating value.

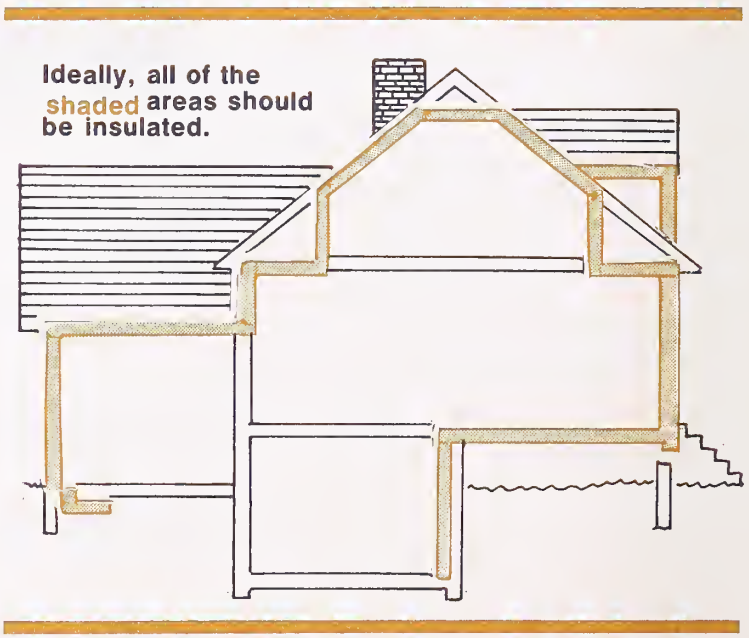
The Federal Trade Commission (FTC) has a regulation covering labelling, testing, and advertising of home insulation materials. FTC's regulation requires that insulation package labels must contain an explanation of R-value and must say what this value is for that particular insulation. A fact sheet giving this information must be available to you. If you buy or build a new home, your contract must include information about what insulation is in the house and what its R-value is.

When you buy insulation, compare the information on the labels or fact sheets. Keep in mind that insulation with a higher R-value for a given thickness is easier to use when space is limited, such as inside exterior walls or in shallow attics. Where more space is available, a product with a lower R-value for a given thickness might be more appropriate since it can be piled higher in the available space. Compare prices and product characteristics.

Insulation is available in standard thickness with given R-values (see chart) or as loose fill that can be installed at desired thicknesses and R-values. The R-values of these standard thicknesses are additive. This means that if a product with a total R-value of R-19 is installed on top of insulation with an R-value of R-11, the total R-value of the insulation will be 19 + 11 or R-30. However, if blankets or batts are installed over loose fill, a slight reduction in the R-value of the original material can be expected because the loose fill becomes compressed.

This ability to compare and add R-values is true for all types of insulation. For this reason, R-value is more useful than inches as a measure. Since materials have different densities, the same thickness of two different materials may have different insulating values. Therefore, when you are speaking to a contractor or supplier about the type and amount of insulation that is correct for your home, express it in R-values, not in thickness.

In the case of loose-fill insulation packaged in bags, the R-value of the final coverage depends on how much area the content of the bag is intended to cover. This information should be clearly explained by a chart on the package. If there is no chart, ask a salesperson or the contractor installing the insulation for a notice from the manufacturer stating the product's R-value and the number of bags you will need to cover the area you plan to insulate to the R-value you want.



To determine which insulation is the best buy, use this simple formula to calculate a price per square foot of R-value (remember that R-values can be added): Take the price per square foot of the product and divide it by the total R-value of that product. This will give you the price per square foot of R-value.

For example, one insulation product is rated at R-11. It costs 15 cents per square foot. Another insulation product is rated at R-19, and it costs 22 cents per square foot. By dividing each R-value into cost per square foot, it is clear that the second product is the better buy (1.15 cents per unit of R-value compared to 1.36 cents), assuming that R-19 is needed.

WHERE TO INSULATE AND RECOMMENDED DEGREES OF THERMAL EFFICIENCY

A rule to follow to find what parts of your house need insulation is that all living (heated) areas should be separated from unheated areas with insulation. Regardless of the house layout, you can use this rule to determine where insulation should be installed. Any areas you miss will allow heat to flow out at a rapid rate. Different areas, however, have different priorities in terms of cost-effectiveness.

In order of cost-effectiveness, the areas you should insulate and the minimum levels you should achieve for Montana weather conditions are as follows:

Attic, floors, ceilings, or rafters	R-38
Basements	
Unheated basement ceilings and heated basement walls*	R-19
Closed crawl space walls or ceilings	R-27
Open crawl space ceilings	R-38
Exterior windows	Add storm windows
Exterior above-ground walls**	R-19

*A heated basement is one in which the temperature does not drop below 55°F. It may contain a furnace or water heater or most of its wall area may be below ground level.

**DNRC does not recommend adding insulation to existing exterior walls. See item 8 in the introduction to this book, and the discussion under "Exterior Walls" later in this chapter.

TYPES OF INSULATION

Before we discuss the actual placement of insulation in your home you need to know something about the many kinds of insulation that are available.

Insulation comes in rolls, strips, boards, batts, and loose fill. You can make the right choice for your needs if you know the characteristics of the different types. This section explains the kinds of insulating materials, and where they generally are used.

TYPICAL R-VALUES OF DIFFERENT KINDS OF INSULATION

R-Values	11	13	19	22	30
	(in inches)				
Loose Fill					
Fiberglass	5	5½	8½	9½	13
Rock wool	3½	4	6	7	9
Cellulose	3	3½	5½	6	8½
Vermiculite	5	6	9	10½	14½
Batts/Blankets					
Fiberglass	3½	4	6	7	8½
Rock wool	3½	4	6	7	8½
Rigid Board					
Polystyrene (extruded)	3	3½	5	5½	7½
Urethane	2	2	3	3½	5
Polystyrene (beadboard)	3	3½	5½	6	8½
Fiberglass	3	3½	5	5½	7½

R-values computed from values given in the American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc. (ASHRAE) Handbook of Fundamentals, 1977.

BLANKETS

Insulation is most commonly purchased in rolls (referred to as blankets) available in varying R-values. They are available in different lengths and widths.

Blankets are easy to use. They can be cut to the needed length and come in widths to fit snugly between rafters, joists, and studs. However, blankets should not be packed into tight places—*compressed insulation has a reduced R-value.*

Rock wool and fiberglass come in blankets and are used in finished and unfinished attics, heated and unheated basements and crawl spaces, newly constructed exterior walls, and floor/ceiling areas.

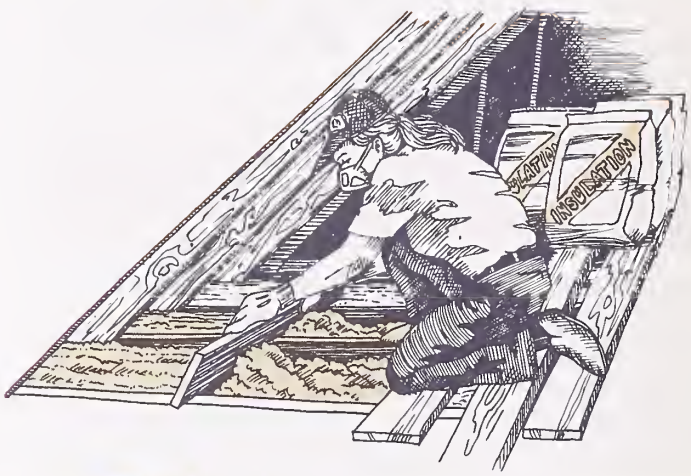
Blankets can be purchased with or without an attached vapor barrier. For ease of installation along walls in new construction, blankets and batts can be purchased with an attached vapor barrier wider than the insulation. This extension can then be stapled or nailed to upright studs. *Remember, the vapor barrier is turned toward the living area and not toward the outside.*

BATTS

Batts are strips or blankets of rock wool or fiberglass insulation that have been precut to 4-foot or 8-foot lengths. Batts are between 15 and 23 inches wide, and can be bought with or without a vapor barrier. Batts are used for insulating unfinished attics, crawl spaces, newly constructed exterior walls, and floor/ceiling areas.

LOOSE FILL

When insulation is packaged in bags and the material can be poured or blown into place, it is called loose fill. Rock wool, fiberglass, cellulose, vermiculite, and perlite can be purchased in this form.



Loose fill is especially useful when trying to place insulation into hard-to-reach areas. It can be used in attics and can be blown into existing exterior walls. Vapor barriers must be purchased and installed separately when using loose fill. Loose fill may settle during shipment, so the bags should be thoroughly shaken before opening to maintain the stated R-value, and the material should be fluffed when it is being installed. After installation it will settle and lose some R-value, but this normally is not significant.

RIGID BOARDS

Rigid boards are usually made of molded or extruded plastic or fiberglass. They are easily installed by gluing, nailing, or stapling to walls and studs and are used on basement walls, on exterior walls in new construction, and in some types of roofs.

Plastic rigid boards should be used only in finished areas and covered with a fire-resistant material such as gypsum board.

SAFETY CONSIDERATIONS

Possible safety risks are a concern when purchasing insulation. This section describes these possible safety hazards.

FLAMMABILITY

To prevent fire hazards, insulation should be kept at least 3 inches away from any heat source. These sources include exposed light bulbs, recessed lighting fixtures (with the exception of "Type IC" fixture—see page 32), and furnace and fireplace flues. Be certain to check for defective wiring and replace it wherever necessary. Taking these precautions will greatly diminish the possibility of a fire.

A more common concern about the fire resistance of some insulation materials is their tendency to spread a fire that has already begun. Most insulation materials, such as fiberglass or rock wool, will not add substantially to a fire because they do not burn under normal conditions. Fire-retardant chemicals have been added to other insulating materials, such as loose-fill cellulose. However, it is important to remember that if a fire should start in a house and if temperatures become high enough, any insulating material may burn or melt.

Look for a Federal Trade Commission, Consumer Product Safety Commission, or testing laboratory label describing the material's flammability. This label should rate flammability by 3 factors: flame spread, (how fast the material will burn); fuel contribution, (how much the material will contribute to a fire); and smoke development, (how much smoke will develop when the material burns). These three categories are rated in comparison to a nonflammable material (rated at 0) and highly flammable material (rated at 100). This provides the consumer with a general range for comparison.

A satisfactory flame spread, fuel contribution, or smoke development rating is below 25. Products rated above 25 for any of the three characteristics should be used only if covered with gypsum board or similar fireproof material. Covering insulation with decorative panels does not satisfy the requirement, since the panels often have higher flammability ratings than the insulation. Materials with ratings above 50 may feed a fire and are therefore not recommended.

TOXIC FUMES

Another concern for the insulation buyer is the possibility of insulation material giving off toxic fumes when it burns. Current home insulation products (with the exception of plastic rigid boards) do not have this problem.

CORROSION

Insulation usually will not corrode metal pipes and wires. However, addition of large amounts of magnesium sulfate or ammonium sulfate to cellulose insulation as fire retardants sometimes causes corrosiveness. The recent passage of federal regulations requiring cellulose to meet certain standards for flame resistance and corrosiveness should eliminate this problem. It is important for the consumer to make sure the product meets these standards.

MOISTURE ABSORPTION

If an insulating material absorbs moisture, it will pack down and its R-value will decrease. A very careful inspection of roofs and other areas for water leaks is therefore very important—*any leaks should be fixed before insulation is installed.* The likelihood of moisture absorption for specific types of insulation is discussed in the following "Insulating Materials" section. If any moisture absorption rating is listed on the package, that rating should not exceed 15 percent.

INSULATING MATERIALS:
What You Need To Know About R-Values

Each type of insulation has its advantages and disadvantages. This section evaluates cellulose, fiberglass, rigid board, rock wool, perlite, vermiculite, and urea formaldehyde foam.

CELLULOSE

Cellulose insulation is made from finely-shredded reprocessed wood products, primarily old newspaper. It is packaged as loose-fill insulation, which is poured or blown into place. Of all the insulating materials available to the consumer today, cellulose is the most strictly regulated. Government regulations require cellulose to comply with strict testing procedures regarding flammability and corrosiveness. Look for a label on the package of cellulose you may be buying to make sure it complies with these requirements.

Cellulose must contain the following statement on all bags or containers: "This product meets the amended Consumer Product Safety Commission standard for flame resistance and corrosiveness of cellulose insulation."

R-value—Cellulose insulation has a relatively high R-value; 3 inches provide R-11.

Flammability—Cellulose is chemically treated with fire retardants that give the material ratings between 15 and 60 for flame spread, 0-40 for fuel contribution, and 0-50 for smoke development. The range in the ratings is due to the varying types and amounts of fire retardants added. Ratings below 25 are satisfactory. Look on the package to ensure ratings of 25 or below.

Toxic Fumes—Not a problem.

Corrosion—Make sure the cellulose you buy conforms to government regulations.

Moisture Absorption—When cellulose is treated with fire retardants, it is also treated to minimize moisture absorption. However, this problem can be reduced with use of a vapor barrier. When cellulose is blown into side walls, it usually is impossible to install a proper vapor barrier. An alternative is to paint interior walls with a vinyl-based paint or to hang vinyl wallpaper.

Shrinkage/Settling—Settling is not a major problem with cellulose unless it has absorbed excessive moisture. However, it is important to shake the bags of insulation before installing, and fluff it while installing it. Don't pack it down once installed.

Installation Considerations—If cellulose should get wet, the material will settle, its R-value will be lowered, and the fire-retardant chemicals may leach out. Precautions should be taken to minimize moisture problems.

When installing cellulose, make sure there is no powdery residue in the bag. That would mean the fire-retardant chemicals have already separated and the cellulose being installed is no longer properly treated for fire prevention. Federal regulations include requirements to minimize this problem.

FIBERGLASS

Fiberglass insulation is made from glass that has been processed into fibers and left as loose fill or made into batts or blankets.

R-value—R-values for fiberglass depend on the form. It takes 5 inches of loose fill or 3½ inches of batts or blankets to provide R-11.

Flammability—Loose-fill fiberglass has a relatively low flammability rating, with flame spread at 10-25, fuel contribution 10-20, and smoke development 0-20. Batts and blankets have slightly higher flammability ratings due to the vapor barrier, but the difference is insignificant.

Toxic Fumes—Not a problem.

Corrosion—Not a problem.

Moisture Absorption—While fiberglass does not absorb moisture, a temporary condition called adsorption may occur on the surface of the fiber. When allowed to dry out, it regains its original R-value. A vapor barrier is recommended whenever possible.

Shrinkage/Settling—Some settling may occur with loose-fill fiberglass.

Installation Considerations—Exposed fiberglass insulation fibers may cause skin or respiratory problems. Precautions should be taken to cover any material after installation in living areas. During installation, direct contact should be avoided by wearing gloves, face mask, goggles, and long-sleeved clothing. Since fiberglass may snag on protruding nails when it's blown into enclosed cavities, a complete fill may be difficult to achieve.

PERLITE

Perlite is a glassy volcanic rock containing a small amount of combined water. When crude perlite ore particles are heated, they expand to form sealed glassy cells. It is these tiny glass-sealed bubbles that account for the excellent insulating properties of perlite and its light weight. The expansion process also creates its distinguishing white color.

R-value—It takes 4 ½ inches of perlite to provide R-11.

Flammability—Perlite is noncombustible and nonflammable.

Toxic Fumes—Not a problem.

Corrosion—Not a problem.

Moisture Absorption—Some perlite is treated with silicone to improve water repellency. A vapor barrier is recommended where possible.

Shrinkage/Settling—Perlite supports its own weight; once installed it exhibits very little settling.

Installation Considerations—Perlite has been used primarily for insulating masonry blocks and cavity walls. Its use for home attic insulation is relatively new.

RIGID BOARDS

Rigid boards are extremely light in weight and made of fiberglass, polystyrene, polyurethane, or polyisocyanurate plastic molded or extruded into rigid boards. The boards are easily installed by gluing, nailing, or stapling to walls and studs. They are used primarily on basement walls and for insulating exterior walls in new construction.

R-value—Rigid boards have high R-values, requiring only 2 to 3 inches to provide R-11.

Flammability—Since the material is flammable when it is used, it should be covered with a minimum of ½-inch fire-rated gysum wallboard, cement plaster, or an equivalent thermal barrier that will provide a finish fire rating of 15 minutes or more.

Toxic Fumes—Many rigid boards will produce toxic fumes when exposed to fire; this is why the ½-inch covering of gypsum board is required.

Corrosion—Not a problem.

Moisture Absorption—Not a problem—many rigid-plastic boards are waterproof.

Shrinkage/Settling—Not a problem.

Installation Considerations—When rigid boards are used, check with local building officials for covering requirements.

ROCK WOOL

Rock wool is made from slag produced in manufacturing steel and has long been used for insulation. The slag is processed from a molten state into a loose fibrous form and made into batts and blankets. Rock wool also can be left as loose fill to be poured or blown into place. Rock wool is commonly referred to as mineral wool or gypsum rock.

R-value—It takes 3 ½ inches of rock wool to provide R-11. Batts and blankets tend to have a slightly higher R-value than loose fill rock wool.

Flammability—Flammability ratings for rock wool are below 25.

Toxic fumes—Not a problem.

Corrosion—Not a problem.

Moisture Absorption—Absorption of moisture by rock wool is not a problem, but a vapor barrier should be used to prevent infiltration of cold air.

Shrinkage/Settling—Some slight settling is the only problem with rock wool, and this only applies to loose fill.

Installation Considerations—Rock wool fibers may irritate the skin or the respiratory system, so it is recommended that fibers not be left exposed. Protective clothing should be worn during installation to minimize fiber contact with the skin. Rock wool fibers may snag on protruding nails when it is blown into enclosed cavities, and a complete fill may be difficult to achieve.

VERMICULITE

Vermiculite is an expanded mineral used as loose-fill insulation. As with all types of insulation, it is the pockets of air in the expanded vermiculite that give the material its insulating value. Because of the consistency of this material, it comes in bags as loose fill ready to be poured in attics by home owners or in masonry blocks and walls by builders.

R-value—Vermiculite requires 5 inches to provide R-11.

Flammability—Vermiculite has the lowest flammability rating of any insulation material with flame spread, fuel contribution, and smoke development all equal to 0.

Toxic Fumes—Not a problem.

Corrosion—Not a problem.

Moisture Absorption—Not a problem, although a vapor barrier should be used where possible to prevent infiltration.

Shrinkage/Settling—Minimal.

Installation Considerations—Vermiculite, like perlite, is used primarily for insulating masonry blocks. It can also be added to existing attic insulation. A face mask is advisable because loose fill can create dust during installation.

UREA FORMALDEHYDE FOAM (UFFI)

Urea formaldehyde foam insulation is an insulation product that is manufactured at the job site by the installer. Urea formaldehyde-based resin—a foaming agent—and compressed gas are fed into equipment to produce a substance with shaving cream-like consistency. The foam is pumped into walls and left to harden. The foam cures into a firm, open cell material.

This foam insulation (UFFI) was installed in about 500,000 homes in the United States in the 1970s, but many people living in those homes developed irritation in eyes, nose, and throat, headaches, nausea, and respiratory problems.

In response to complaints from home owners, the U.S. Consumer Product Safety Commission conducted studies in 1982 and determined that UFFI presented an unreasonable risk of injury to the public. The CPSC voted to ban the installation of UFFI in homes and schools.

This ban was overturned after industry challenges led to court decisions concluding that clear evidence of risk was lacking. There is no federal ban on the installation of UFFI.

HOW TO FIND OUT IF YOU HAVE UFFI IN THE WALLS

If you purchased a home before 1970 and have not added insulation, you probably do not have UFFI. If you bought a home after 1970 and wish to determine if you have UFFI, you may want to check with the builder, realtor, or former owner. If you had insulation added to your home, check with the installer or read either the contract or bill of sale.

There are several ways you can detect whether your house is insulated with UFFI.

You can check for patched holes either on the outside or inside of the house; however, other kinds of insulation may have been blown in.

Check electrical outlets and switch plates on outer walls. Turn off the power before you remove the switch plates. Foam may be visible around or behind the outlet, but may not be UFFI—there are other foam-like sealers that don't contain formaldehyde.

More information on this possible source of indoor pollution is given in Appendix A of this book.

CORRECT INSTALLATION

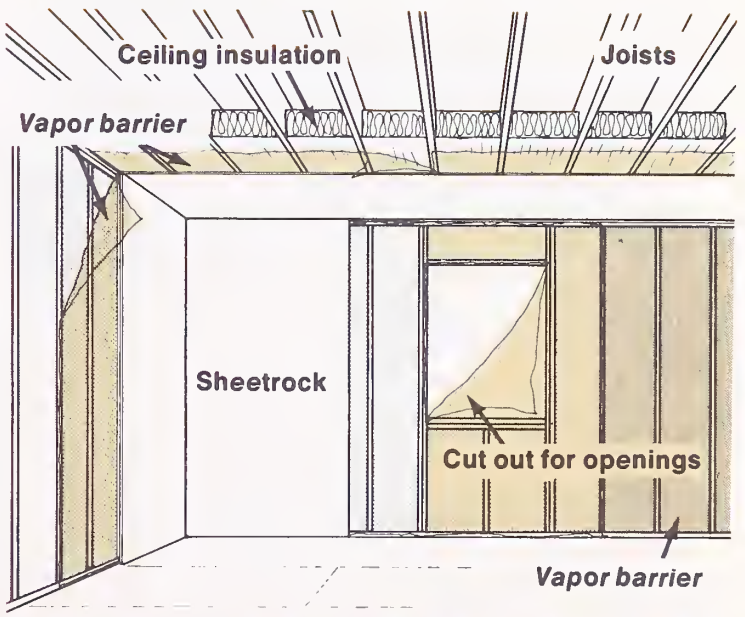
First Install A Vapor Barrier

Insulation installed without a vapor barrier will collect moisture that ordinarily passes from living areas to the outside. Kitchens, laundry areas, and bathrooms release especially large quantities of moisture, which will dampen unprotected insulation, causing it to compress and decreasing its insulating qualities. Therefore, it's important to install a vapor barrier between the insulation and living areas. Usually vapor barriers are made of kraft paper, foil, or plastic. That surface faces the "warm" side. Kraft paper or metal foil are often already attached to the insulating batts or blankets you buy.

If you install vapor barriers correctly you can enjoy the comfort of a better indoor climate, because your home will retain adequate humidity and maintain an even temperature more easily.

Many new homes in Montana are built with a continuous polyethylene vapor barrier, or drywall covered with a vapor-barrier paint. These vapor barriers completely enclose the home's living area, greatly reducing infiltration and moisture penetration through the insulation. A home owner who has this type of continuous vapor barrier installed should realize that reducing infiltration can cause problems, too. Buildup of moisture on interior walls can cause gypsum board to sag, or window mouldings to warp. Indoor air pollution may increase if proper ventilation isn't installed. For more information on the safe installation of a continuous air vapor barrier, contact DNRC.

Walls and Ceiling Vapor Barrier



Follow the Instructions

Any type of insulation gives best performance only when properly installed. Be sure to follow the instructions that come with the type you choose. One common mistake is "packing" insulation into the spaces to be insulated. Compressing insulation materials forces air out of them and decreases their resistance to heat flow.

Other installation practices or structural characteristics of homes that decrease the value of insulation materials are discussed in "Attic Bypasses."

To determine how many square feet of insulation you need for a floor, ceiling, or roof, measure the length of the space to be insulated and

multiply it by the width, then subtract 10 percent to compensate for joist or rafter space. This may already have been calculated by the insulation manufacturer. Read the package label carefully.

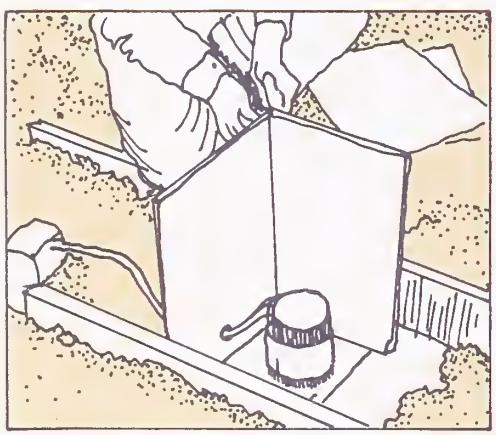
Several tools are required to install insulation. Most types of insulation require a utility knife or large shears, a tape measure or ruler, a heavy duty staple gun, a roll of duct tape, sufficient lighting, safety glasses or goggles, a breathing mask, and heavy clothing. (See the section on "For Your Protection" for more details.) If your attic has floorboards, you will also need a hammer and pry bar to remove enough of them so you can get the insulation in. CAUTION: Before insulating, check for and correct leaks or moisture problems. Wet insulation will not insulate properly and may increase structural damage. Never cover recessed lighting fixtures, furnace flues, motors or other heat sources, or ventilation openings with insulation. Make noncombustible baffles or collars to surround these items so insulation will remain at least 3 inches away from them. Box chimneys to prevent any contact of insulation with the chimney. Montana codes prohibit filling the space around a chimney or stack with any material.

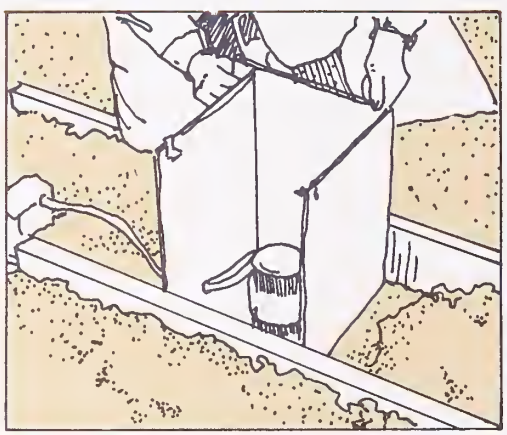
If the insulation is being placed over wiring, make sure the wire insulation (covering) is in good condition.

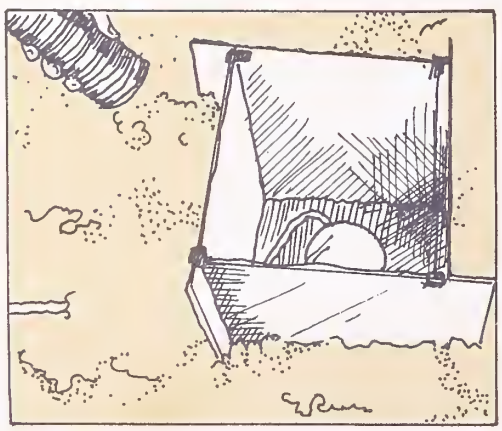
Insulation over flush-ceiling mounted light fixtures with two or more bulbs also can trap heat. However, some fixtures have been tested and listed by manufacturers for installation under insulated surfaces. These fixtures are called "Type-IC" and went on sale in 1978. If an IC fixture is not used, permanently keep insulation at least 3 inches away from the sides of the fixtures. Never insulate over any other type of fixture.

Before insulating, check all your light fixtures in areas being insulated and install only correct wattage bulbs. If the fixture does not have a label stating the acceptable bulb wattage, it probably is rated for a 60-watt bulb. Bulbs of too high a wattage may cause a fixture to overheat.

Never cover recessed lighting fixtures, furnace flues, motors or other heat sources—







Never place insulation over "knob and tube" wiring systems (where the wires are in ceramic "tubes" held away from wood by ceramic "knobs") found in some older homes. If other types of wiring are to be buried in insulation, be sure to have the fuse size consistent with the wire size: a 15 amp fuse for #14 wire or a 20 amp fuse for #12 wire.

Attics without floorboards will require that you lay large boards or sheets of plywood across the joists to support your weight while you work. Don't risk falling through the ceiling.

When there are no floorboards, batts, blankets, or rigid boards can be cut to length and simply laid between the floor joists. Make sure you leave no gaps between the pieces of insulation or between the insulation and the joists. If you use loose-fill insulation, empty the bags into the spaces, fluff the material, and level it with a large board or garden rake.

In using insulation with a vapor barrier attached, place the vapor barrier facing the floor, and tape over any tears or rips with duct tape. If you use loose fill, put down a vapor barrier before you install the insulation. Use polyethylene plastic or heavy kraft paper that is designed to be used as a vapor barrier. Again, be sure to tape all tears and to overlap the barrier sufficiently to prevent leaks.

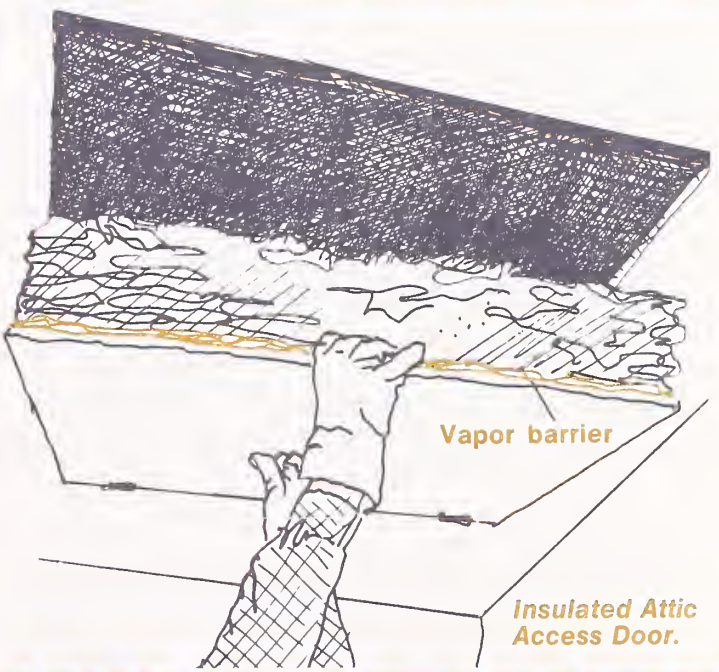
You may have to remove some attic floorboards so you can push the insulation into place with a long stick. A contractor can use machinery to blow loose-fill insulation under floorboards. With loose-fill insulation, you should use vinyl paint on the ceiling below to provide a vapor barrier.

When placing new insulation over old insulation, *never* put a vapor barrier between the two. If you are using insulation that has a vapor barrier backing, slit the barrier to allow the passage of moisture. Otherwise, the moisture will be trapped in the old insulation. You may place any type of insulation on top of other types. Insulate at least to joist height. When using batts or blankets, lay the ones on top of the joists at right angles to those between the joists.

Install insulation on knee walls by standing up batt insulation in the spaces between the wall studs if they are exposed, and holding it in place by criss-crossing nylon string or thin wire back and forth across the space. The string can be attached to nails driven into the faces of the studs. Make sure the vapor barrier faces the heated area. You can also staple or nail rigid board insulation between the studs and cover it with half-inch gypsum board or other fire-resistant material. If the studs are not exposed, glue or nail rigid board insulation to the wall surfaces and cover with fire-resistant material.

Under no circumstances should you block the attic eave vents with insulation. Adequate ventilation is vital to prevent moisture problems.

Don't neglect to insulate the attic access door.



Insulated Attic Access Door.

For Your Protection

Some fire retardent chemicals and glass and mineral fibers may cause skin irritation, so you should wear protective clothing such as a long-sleeved shirt, long pants, shoes, and gloves, and goggles. Wear a dust mask or a respirator to avoid breathing small fibers.

Wear a hard hat to avoid injuring your head in closed spaces or where nails are protruding, as in an attic. When working above a single ceiling, use boards or plywood to stand on. Don't risk a fall.

If you must install insulation during warm weather, try to do it during the coolest part of the day to avoid heat exhaustion.

When you begin insulating, be careful not to lift or pull wires. As wiring ages, the wire's insulation may become brittle and you may damage the wire or cause an electrical shock.

WHERE TO INSULATE FIRST—ATTICS OR ROOFS

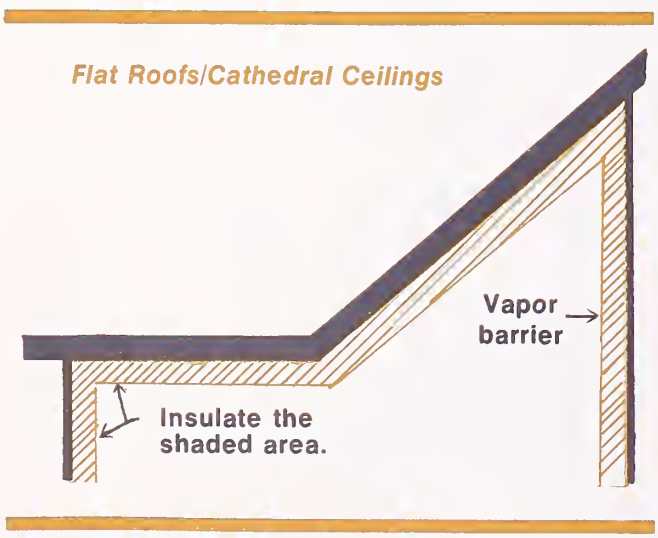
Since hot air rises, the first place to consider insulating is the attic or roof. If you are not the original owner of your home, you may not know whether that area has been insulated. Fortunately, it is the simplest place to check—just look between the attic floor joists. Be sure to check the entire attic, since some older homes may have only partial coverage. If there is flooring in the attic, it may be necessary to pry loose a floorboard to make this determination. Test more than one place to determine whether there is total coverage. If you have room additions, check those too. To find the R-value of your insulation, measure the depth in inches and consult the chart on R-values.

NOTE: If you already have 2 or 3 inches of insulation (around R-11) in the attic, adding more insulation is not as cost-effective as it would be to add insulation to an attic that has none. Insulation obeys the law of diminishing returns—beyond some point, additional insulation costs more than it saves.

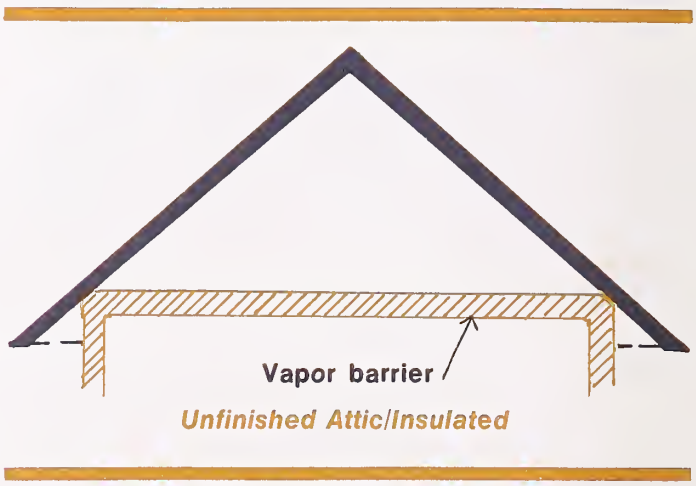
Types of Attics or Roofs

Strategy for insulating the following types of structures, and any others you encounter, should be easy if you remember to separate heated from unheated spaces.

1. Flat Roofs or Cathedral Ceilings. The entire roof or ceiling area should be insulated. However, these types of roofs are difficult to insulate after the building has been constructed. You can insulate when you have the roof replaced or you can add insulation to the ceiling. Of course, the latter option may require lowering the ceiling. Otherwise, you can insulate the ceiling with rigid boards or batts covered with gypsum.



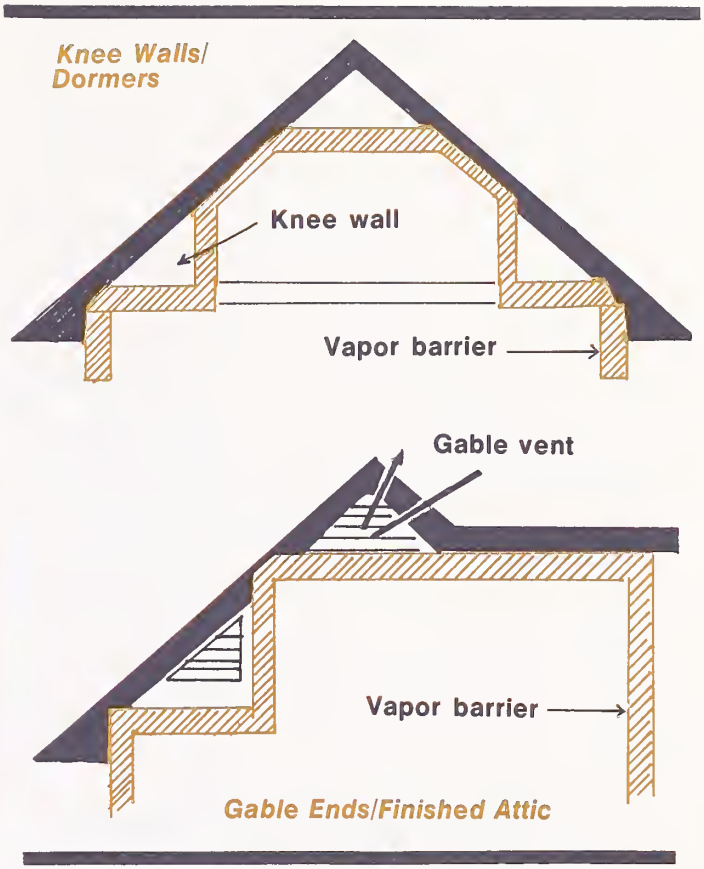
2. Unheated, Unfinished Attics. There are two basic types of attics: open, unused, or storage attics; and finished, sectioned, or heated attics. Existing finished spaces are more expensive to insulate. As you can see from the illustrations, much less material is needed to insulate an open attic than a sectioned attic with knee walls or dormers. Sectioned, lived-in attic areas are already finished and insulating behind finished surfaces is more difficult.



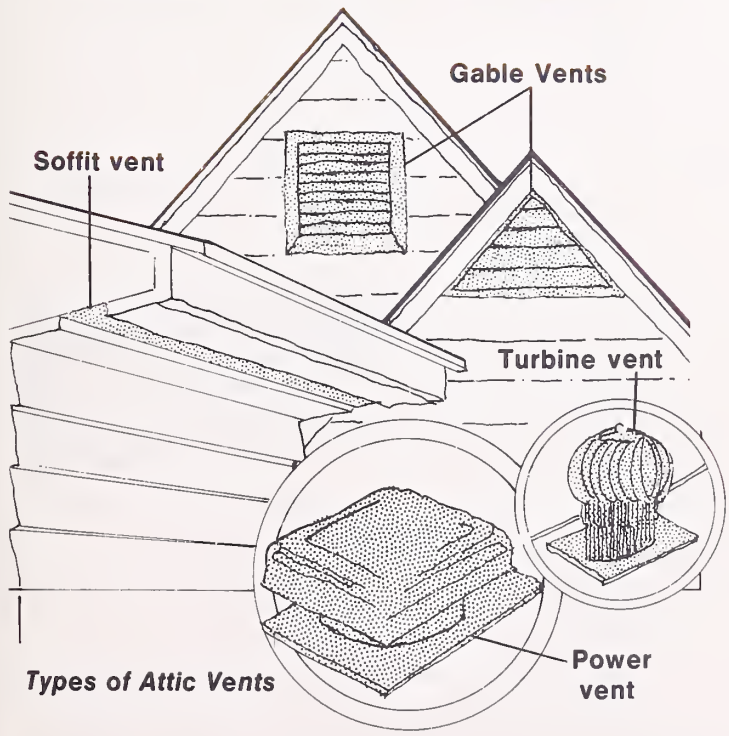
Notice that it isn't practical to insulate between the rafters of an open, unused attic, because the heat is not stopped at the lowest practical level, which is the ceiling. Insulating the rafters would, in effect, trap heated air in the attic where it is unneeded. Similarly, as

shown, it is not effective to insulate the floor areas behind the knee wall in a sectioned attic without also insulating the knee walls, hip roof sections, and gabled ends. Insulating only the floor areas would divert heat flow from those insulated areas to the uninsulated areas and to the outside—a great deal of heat would still be lost. Insulate the shaded areas shown in the illustration.

3. Finished Attics with Knee Walls or Dormers, or completely finished attics. Insulate the shaded areas (see illustration).



Attic Ventilation



Types of Attic Vents

After an attic has been insulated, temperature differences between living spaces and attic space should be greater than before. If not, your insulation is not working properly; you probably have an "attic bypass" of some sort. In winter, the attic will be quite cold and in summer, very hot. These temperature contrasts can cause two problems. The first is that, especially in winter, moist, cold air will tend to condense in the attic, reducing the R-value of the insulation and possibly causing moisture damage to wood structures in the attic. The second problem is that the summer heat trapped above an insulated floor may make it more difficult to cool the house. The solution to both of these seasonal problems is adequate attic ventilation.

The standard to follow is this—if you have a vapor barrier in the attic, there should be a minimum of 1 square foot of free venting area for every 300 square feet of attic floor area. If there is no vapor barrier, you must have 1 square foot of free venting area for every 150

square feet of attic floor area. The venting area should be divided between intake vents placed as low as possible and outlet vents placed as high as possible. Venting devices can be purchased in many sizes and types and most can be installed with minor carpentry skill. Vents are to be left open all year. If your house already has soffit vents, don't cover them with insulation. Check any existing vents to make sure they aren't blocked by debris. If the attic has windows, consider converting one on each end of the house to a vent. Any venting you install should be designed for cross ventilation and maximum air flow through the entire attic. If the attic area requires that insulation be installed between rafters, soffit and ridge vents must be installed in order to prevent damage to rafters from condensation. NOTE: Power ventilators probably aren't cost-effective; passive vents, if properly sized, should be sufficient to provide adequate ventilation.

Attic Bypasses

Substantial heat loss can occur through uninsulated pathways. The paths that allow heat to bypass the insulation must be located and sealed.

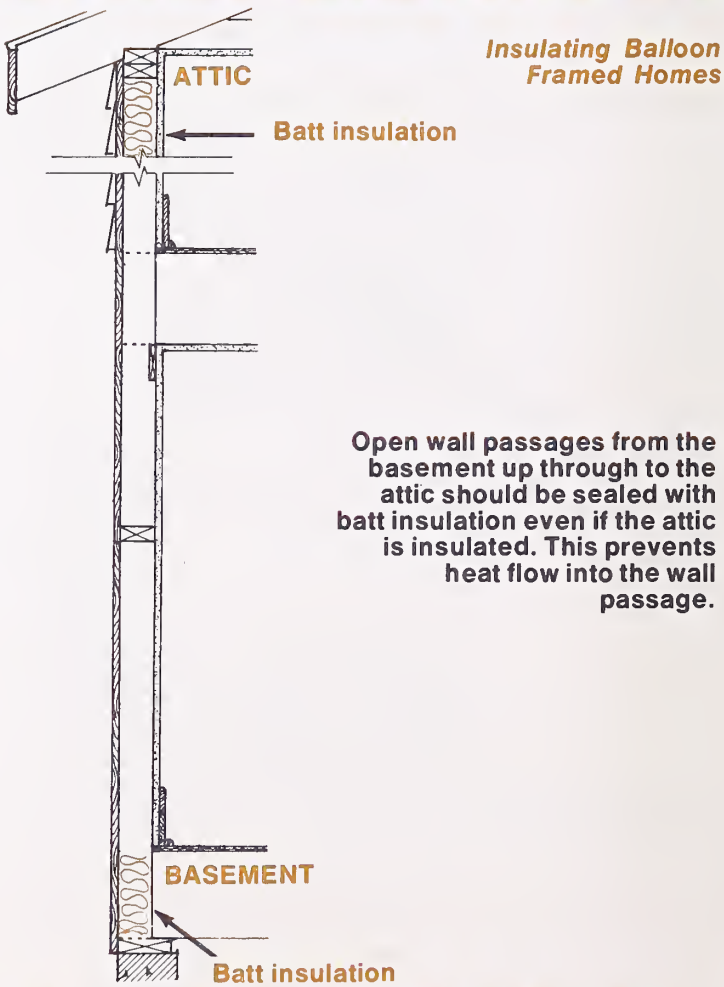
The following list is a reminder of some common bypass paths that you should look for and correct.

1. Partially insulated attics. Remodeling or additions may result in places where insulation was not installed.

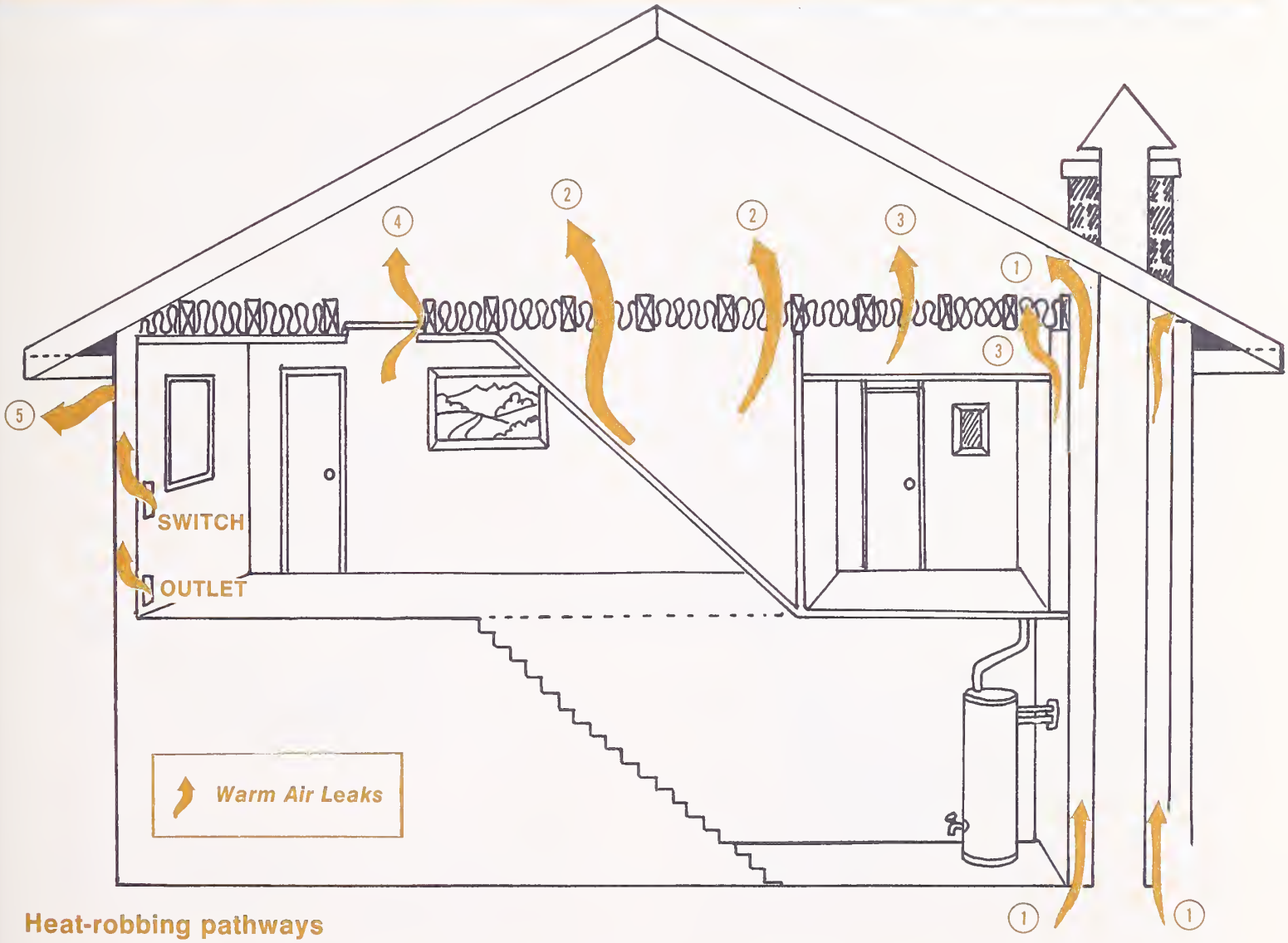
2. Gaps in the insulation. Sometimes when batts, blankets, or loose fill are installed in the attic between the joists, there may be spots not covered, or gaps between the joists and the insulation or between the pieces of insulation. Remember, be careful not to cover recessed light fixtures or vents, but check for other uncovered or missed spots. One way is to go up into the attic when it is dark and the lights are on downstairs. See whether you notice any light shining through the attic floor.

3. Uninsulated, unsealed attic access doors. Be sure to insulate the door leading into the attic and to weatherstrip it to seal cracks or gaps.

4. Open shafts around furnace flues. Montana building codes prohibit filling open shafts around chimneys or flues with insulation of any kind. Be sure to follow manufacturing instructions when installing furnace or stack.


Insulating Balloon Framed Homes
ATTIC
Batt insulation
BASEMENT
Batt insulation
Open wall passages from the basement up through to the attic should be sealed with batt insulation even if the attic is insulated. This prevents heat flow into the wall passage.

5. Balloon construction or party walls. If you have an older house with balloon construction (the wall cavities are open from basement to attic) or a townhouse with an interior party wall separating your house from the next house, you may have an open passage in the walls leading from the foundation up into the attic. Heat will flow into the wall cavity and out the attic, bypassing the attic insulation. This is easily sealed by stuffing batts at the bottom and top of the passage in the basement and the attic. Insert only enough batting to seal the passage; it's not necessary to fill the entire cavity with insulation.



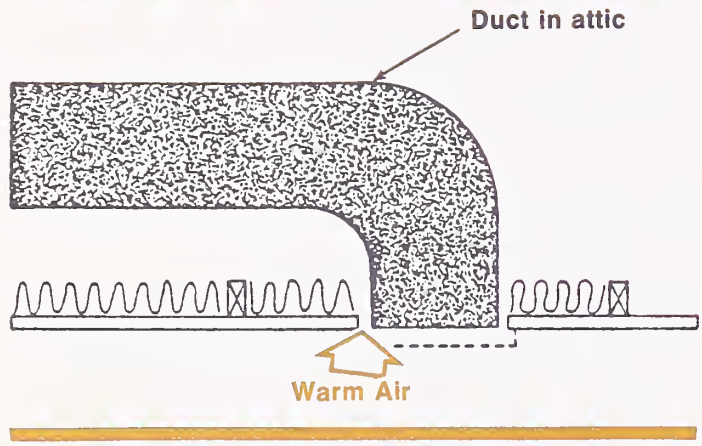
Heat-robbing pathways

1. Sheet metal flue from a furnace or a masonry chimney.
2. Spaces above staircase ceilings.
3. Spaces above dropped ceilings.
4. The attic access/entry door.
5. Electrical switches and outlets outside the house located on exterior walls.

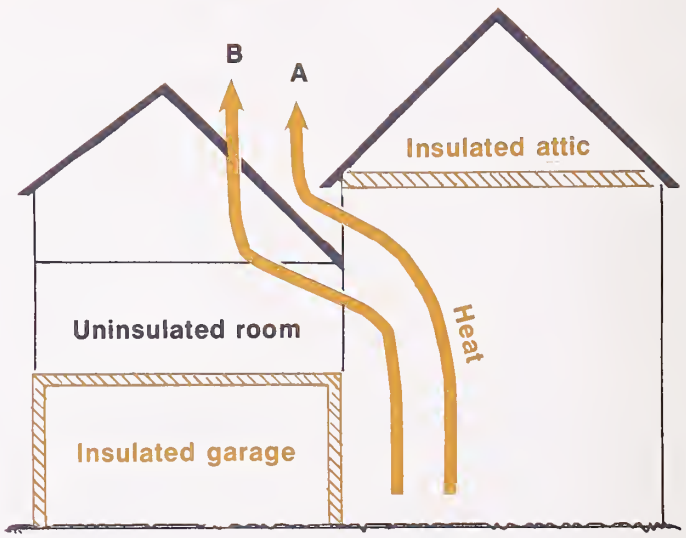
6. Electrical switches and outlets inside the house located on exterior walls. Air leaking through these outlets travels within the wall cavity and passes to the outside. Depending on wind conditions, cold air from the outside can enter a house along the same path. Dirt behind the switch plate or outlet cover is one sure sign of a leaky outlet. These leaks can be stopped with inexpensive foam rubber gaskets. Installation involves simply unscrewing the rectangular plate that covers the outlet or switch, placing the foam gasket behind the plate, and screwing the plate back on.

7. Warm air leakage along the perimeter of duct openings in the attic floor. The dampers

on air conditioning ducts that run through attics should always be closed securely in winter.



NOTE: If you compare the temperature in the attic with that of living spaces and find that there is consistently less than a 15°F difference, your insulation is probably being bypassed and you should look for these possible leaks. The illustration to the right shows a common case. There is no insulation over the room built above the garage, and heat from the house bypasses the insulation in the attic, as indicated by the arrows. To correct this, insulate both the small section of wall between the two attic floors and the attic over the garage room. Insulating only the floor over the garage room will not correct the bypass, since the heat can still escape via arrow "A."



Bypass Phenomena in Balloon Construction or Party Walls.

FOUNDATIONS

The foundation level of a home is usually neglected, although it is a source of excessive infiltration and, in many cases, a medium for considerable conductive heat loss. The mass of masonry or concrete walls, for example, retains cold very effectively, creating a temperature difference and heat loss. And until recently, basement windows were of poor quality, allowing leaks around loose-fitting frames and mountings in the masonry or concrete. Metal frame basement windows are also notorious for leaks and the metal acts as a conductor of heat. The wood frame area above the foundation wall provides small protection, since the basement or closed crawl space is separated from the outside only by several inches of wood.

Shallow crawl spaces, especially those with dirt floors, do not even provide the stabilizing mass of a masonry wall and they allow even more conductive heat loss. Homes with open crawl spaces, converted resort homes that rest above ground, and mobile homes without skirting and insulation have no protection whatsoever. Heat loss is magnified by the wind in these cases.

Slab foundations present special problems, too. Slabs are great conductive masses at ground level and siphon heat into the ground. They can also cause discomfort from cold floors and may create moisture problems.

The most common foundation constructions are the following:

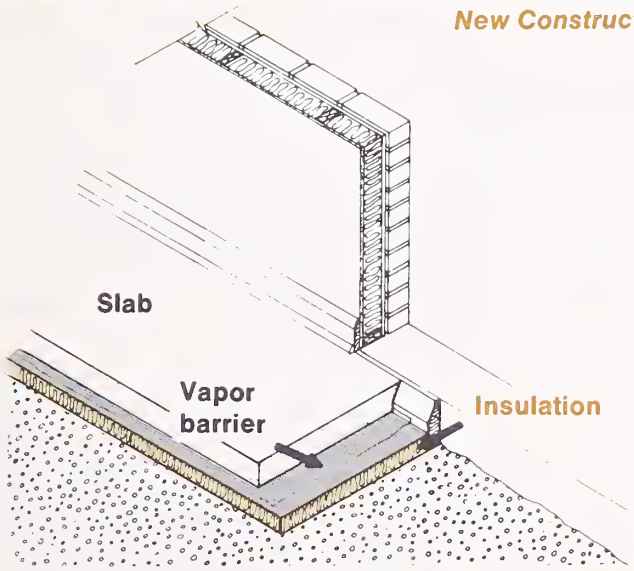
1. Poured slabs, 6 to 10 inches thick, resting at ground level.
2. Basements, heated or unheated, 7 to 9 feet high, with walls of concrete, block, or stone.
3. Closed crawl spaces, 2 to 5 feet high, with masonry or concrete walls.
4. Open crawl spaces under mobile homes or homes on pilings or block supports.

This section discusses how to retrofit these structures. If your foundation is a combination of the above types, read each of the applicable sections.

Slab Foundations

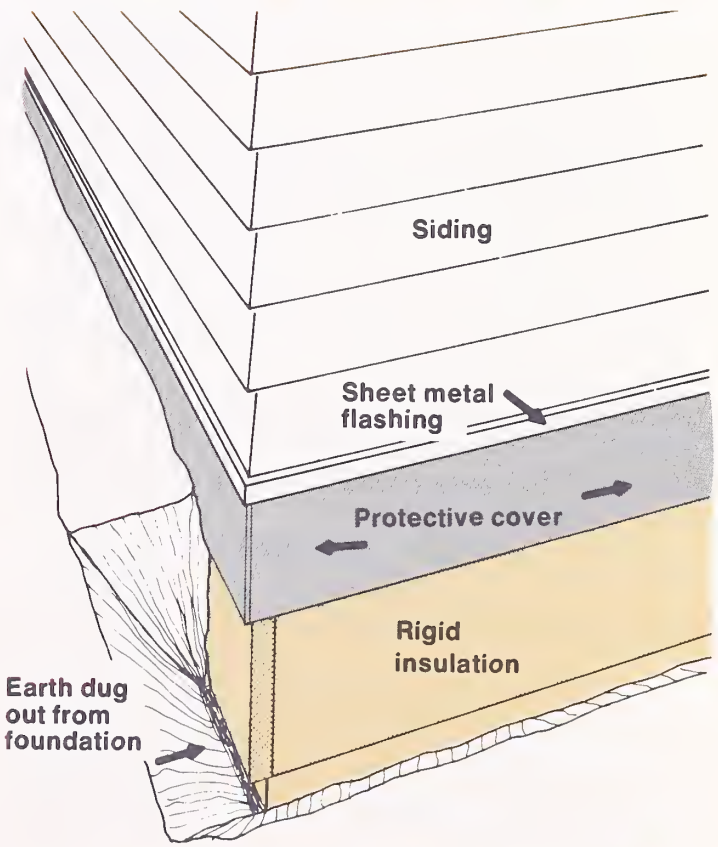
Slab foundations are energy wasters because of their high conductive capacity. When the weather becomes cold, the slab floor will cool and may drop below freezing. In addition to creating severe discomfort, cold slabs may cause water and ice to condense on the floor, damaging wood and carpets. If you are building a new house with a slab floor, insist that the slab be insulated during construction.

New Construction

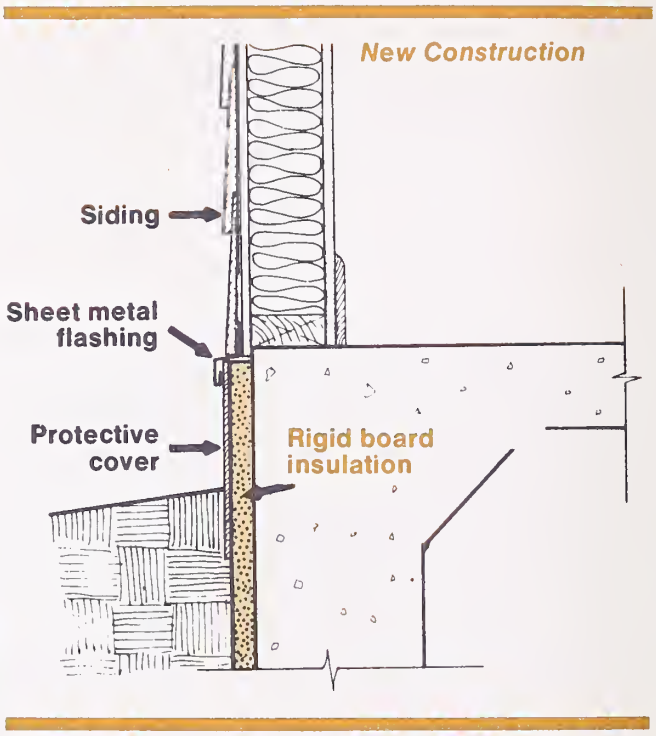


Retrofitting an uninsulated slab is possible, although a major undertaking. Insulation must be placed between the slab and the surrounding dirt around the entire perimeter of the slab. First, dig a trench to expose the sides of the slab. Ideally you should insulate the slab to the bottom of the footing. Dig the trench at least 1 foot deep. Wash the sides of the slab and place 2-inch rigid insulating board (extruded polystyrene is commonly used) against them. Special adhesives that do not react chemically with the insulation are used to glue the boards to the slab. Rigid boards can degrade when exposed to sunlight and lose some of their insulating value, so before backfilling, you must protect the portion of them that will be exposed above ground level. A stucco-like finish can be trowelled onto the boards, metal flashing can be applied, or you can use a rigid plastic sheet that is made for this purpose only.

Retrofitting Existing Construction



If moisture problems appear, they may be from one of two sources and are remedied differently, depending on the source. In the first case, moisture may be migrating up from the ground through the slab and into the house. To stop it, seal the slab with concrete sealer, vinyl paint, plastic, or some other product made especially for this purpose. You can do the same thing for basement floors. In the second case, moisture from inside the house may be condensing on the slab floor if the slab is cold. The options here are more costly. You can retrofit the slab so it will not get so cold or you can use a dehumidifier to remove some of the inside moisture. Using a dehumidifier is expensive, but less so than retrofitting the slab.

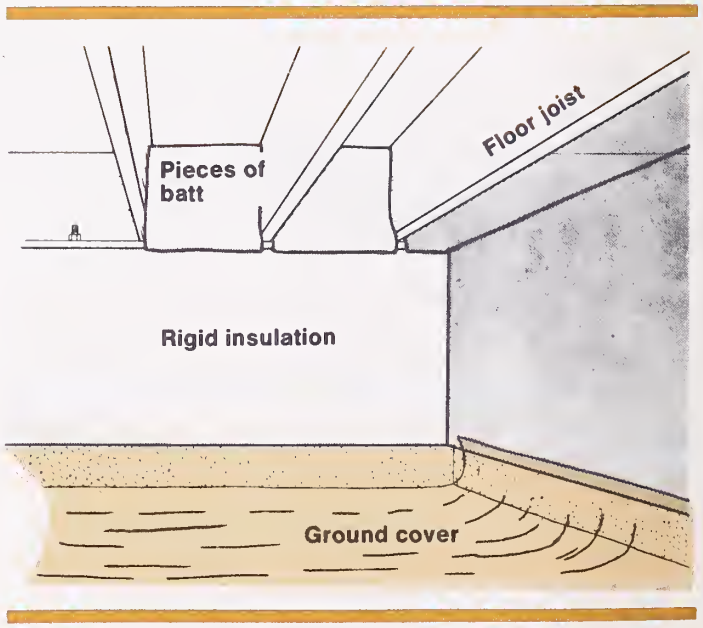


BASEMENTS

There are several crucial but inexpensive conservation actions that can be taken in basements.

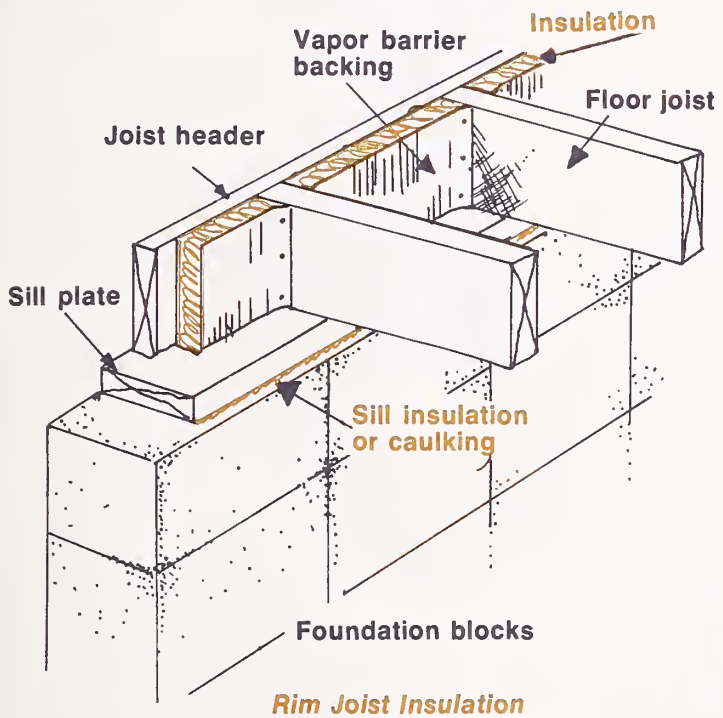
1. Caulk, weatherstrip, and cover basement windows with plastic or install storm windows; repair all broken glass.
2. Weatherstrip any doors leading from the basement to the outside, and weatherstrip any doors leading from an unheated basement into the living areas.
3. Repair or caulk cracks in the foundation walls and caulk pipe and wire entrances from the outside into the basement.
4. Two cost-effective conservation actions you can take are to caulk the sill plate and insulate the rim (or band) joist where the wood frame meets the foundation along the perimeter of the basement. This is discussed on the following page.

You may also want to insulate the basement walls or ceilings, but this is more costly.



Rim Joist Insulation

Besides sealing and adding storm windows or plastic to basement windows, you can retain much of the heat from your basement and first floor areas by installing inexpensive rim joist insulation. This will also lower infiltration problems. If you are building a new house of more than one story, make sure that the rim joist between levels is insulated also. The savings from insulating your rim joists are so great that this can easily pay for itself within a few months.



Rim Joist Insulation

The top of your foundation is a critical joint in your house. Insulating the rim joist can limit infiltration problems and provide an R-value of 11 to 19 at the cold ground level of your foundation, where much heat is lost.

As you can see in the illustration, the rim joist has openings between the floor joists 15 or 23 inches wide, 6 inches deep, and 10 inches high. The rim joist, which is perpendicular to the floor joists in the basement ceiling, is often exposed its entire length. To insulate this area, you will need sufficient R-11 or R-19 foil-backed fiberglass insulation 15 or 23 inches wide, a pair of shears or a utility knife, a staple gun, a tape measure or ruler, a breathing mask, and safety glasses. Simply cut pieces of fiberglass the size of the openings and set them in, stapling and taping the backing to the floor joists. The vapor barrier should face you. You can also use rock wool batts or rigid board. Leaving a space 1 inch wide between the insulation and the rim joist increases the insulating value, but be sure the insulation is sealed tightly along the entire perimeter of each piece you insert. Caulk the sill plate first. If there is a large gap between the sill plate and the foundation wall, stuff it with strips of fiberglass before caulking.

Deciding Where To Insulate

Where to insulate in "heated" (above 55°F) basements is a controversial issue, and opinion is divided. The issue is further complicated by the fact that insulating basement walls is considerably more difficult and expensive than insulating basement ceilings.

If there is no furnace in the basement, if you do not use it as a living area, and if it gets very cold because much of the foundation wall is above ground, you may want to consider insulating the basement ceiling. If you do insulate, also seal any doors leading from the basement to living areas of your home.

If your basement is warm, if you spend time there, or if you plan to turn the basement into a finished area in the future, do not insulate the ceiling. If you want to insulate more than the rim joist, insulate the basement walls. On the other hand, if you don't use the basement and never plan to finish it, if there is little leakage from your heating system into the basement, and if furnace ducts or pipes can be insulated, you can insulate the basement ceiling if you wish. If you do insulate the ceiling, you must insulate all water pipes, water heaters, and ducts in the basement because insulating the ceiling will lower the temperature of the basement.

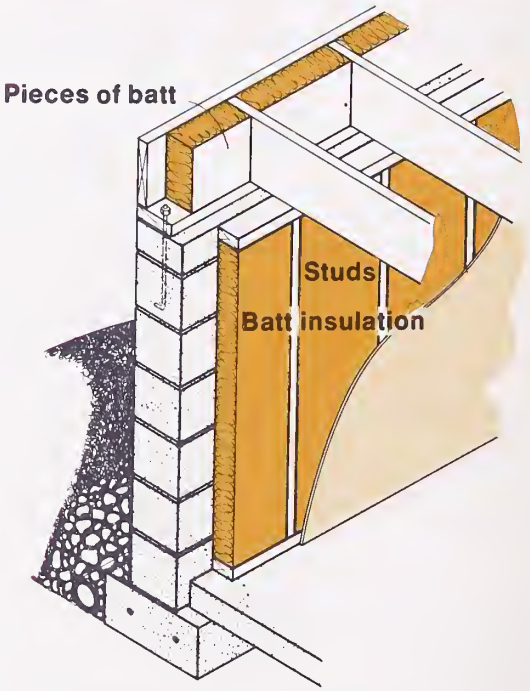
Insulating Basement Walls

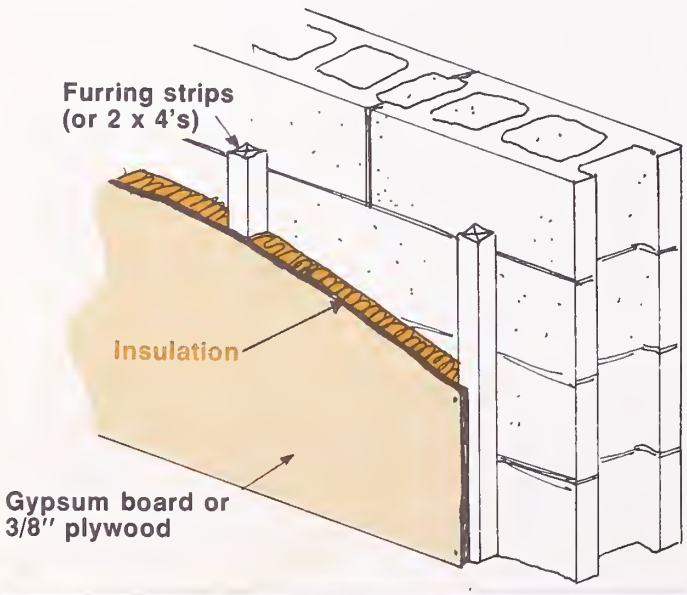
Batt insulation 3½ inches thick (R-11) or rigid board approximately 2 inches thick (R-7) is good for use on basement walls. If you are going to install fiberglass batts you must have some form of framing to provide a raised surface for mounting the insulation. Before you do this, attach a plastic sheet to the wall. Next, assemble a stud wall. Anchor 2 x 4s to the floor as a bottom plate and to the floor joists overhead as a top plate.

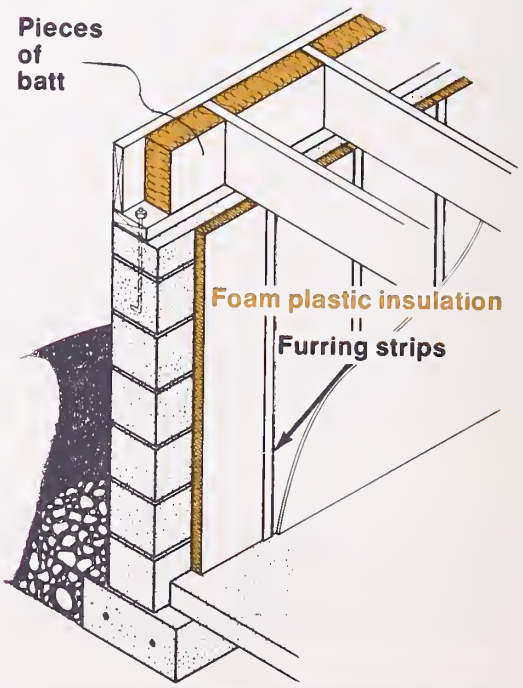
Attaching 2 x 4s to the floor requires that they be anchored to concrete or masonry. You can drive masonry nails, or you can drill holes in the concrete, and install lead shield anchor bolts to hold the bottom plate. You can also use a power-actuated stud gun to nail the bottom plate down. In any case, wear goggles to protect your eyes from chips. Next, nail 2 x 4 studs on 24-inch centers and install fiberglass in the spaces. Use fiberglass (or rock wool) with an attached vapor barrier and install it so that the vapor barrier faces you. If you wish, you can finish the wall with plaster board, gypsum, or paneling.

When you begin, be certain that the walls have no cracks or openings in them. Rigid board insulation can be glued directly to the wall, but durable waterproof glue must be used. Plastic rigid boards are toxic if burned, so must be covered with ½-inch gypsum board.

The following illustrations show three ways to insulate basement walls.





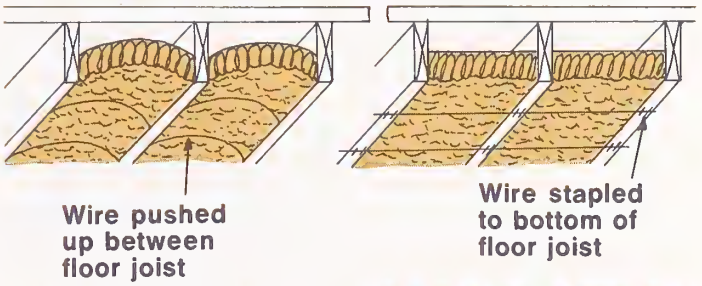


Insulating Basement Ceilings

Insulating basement ceilings can be tricky because wires, pipes, and other obstructions get in the way. Be careful not to leave gaps in the insulation when you install it. The idea is to put batts or rigid boards between the joists. Have the vapor barrier face upward toward the living area. You can also leave a 1-inch air space between the insulation and the floor material to provide extra insulating value. Batts can be suspended with wire mesh, or with wire or string lacing.

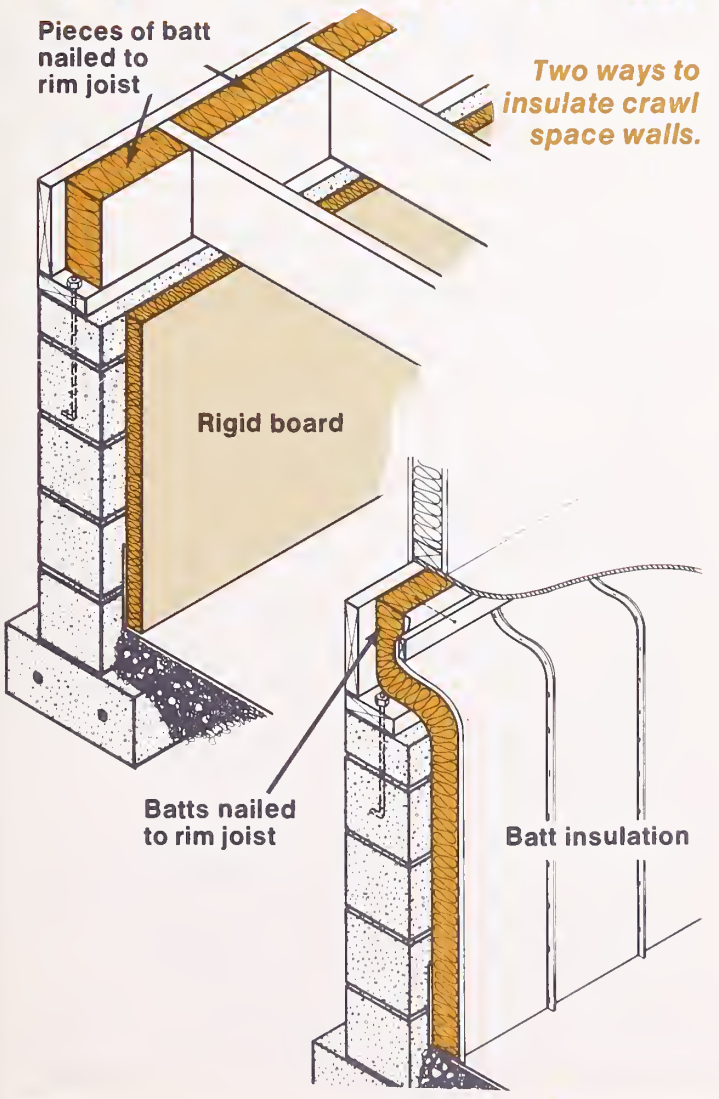
The same procedures are used in insulating crawl space ceilings. In either case, remember that you must be careful to insulate any pipes or duct work in the basement or crawl space and to insulate the rim joist.

Insulating Basement Ceilings



CAUTION: Because the vapor barrier is toward the upstairs living space, the bare side of the insulation is exposed to the basement air, which may result in loose glass fibers falling free. DNRC recommends covering the insulation with gypsum board to prevent this.

Open and Closed Crawl Spaces


Pieces of batt nailed to rim joist
Two ways to insulate crawl space walls.
Rigid board
Batts nailed to rim joist
Batt insulation

If you have open crawl space areas, insulate under the floor with R-19 insulation, using the same installation practices described above for insulating basement ceilings. You also should build a protective "skirt" along the perimeter of your house to help keep out the wind.

If you have a closed crawl space, you may insulate either the floor under the first story using the same procedure as with open crawl spaces, or you may insulate the crawl space walls as described below. In either case, do not neglect rim joist insulation, and, if you insulate the ceiling, insulate pipes and ducts in the crawl space area. In either case, cover the ground with a heavy plastic sheet or moisture problems may develop.

Follow the technique illustrated. Use batts attached either to the rim joist or to a new piece of wood, or glue rigid boards directly to the crawl space wall.

CANTILEVERED STRUCTURES

Any foundation areas that have protruding or cantilevered structures (such as bay windows) should have the floors of these insulated and treated as though they were unheated crawl spaces. As always, vapor barriers should face the heated area.

ATTACHED GARAGES

Many newer homes are built with living spaces either next to or above attached garages. Since most garages are unheated, partitions between the house and the garage should be considered exterior surfaces. This means that all doors between the garage and the house should be of exterior quality and fit tightly. Surfaces separating living spaces from the garage area should have R-11 insulation installed, with the vapor barrier facing the living space of the house. If the garage ceiling is already finished with gypsum board and there is a living area above it, insulate over the gypsum board. If the garage ceiling is not finished and joists are exposed, use batts or blankets and anchor them with wire or string.

Once you have isolated the garage from the living space, it's worthwhile to seal off doors and windows from the garage to the outside so that the garage area can serve as a buffer zone between the outside and living areas. Caulk and weatherstrip windows and doors in the garage, and keep them closed whenever possible. Air leaks around overhead garage doors can be a particularly difficult problem to solve. The first step is to make sure the door is operating properly and that the tracks and other hardware are rigidly installed. With the door closed, move the exterior door stops so they are tight with the door, yet allow the door to move freely. In some cases, rubber gasketing can be added to these side pieces, much as you would around regular exterior doors, though the sliding motion of these doors may cause rapid deterioration of the gasketing. You can seal the top and bottom of the door with heavy rubber gasketing available in hardware stores and made specifically for this purpose. Cracks between garage door panels can be sealed with duct tape or other heavy material stapled to both panels with enough slack to allow operation of the door without ripping the material.

Any exposed heating ducts or water pipes within the garage should be insulated to prevent heat loss and freezing of water pipes.

EXTERIOR WALLS

If you are building a new home, DNRC's Energy Division recommends that you insulate the exterior walls (walls separating living spaces from the outside) to at least R-11, preferably R-19. We do not, however, recommend adding insulation to walls in existing residences. Adding insulation to walls after the house is built is expensive and the quality of the installation, and therefore the effectiveness of the insulation, is very difficult to check. If you have a house that has two or more stories and find that your exterior walls are very cold, you might consider adding wall insulation. Just remember, however, that there are other priorities. Especially in the case of a one-story house, the money it would cost to add wall insulation can save more energy if spent on other conservation actions.

If you consider adding insulation to your walls, keep the following in mind: it probably isn't worth it if they already have some insulation. The slight gain in R-value achieved probably would not save enough energy to recover your investment. If you are not sure whether there is insulation already in your walls, remove the switch plate from one of the interior light switches on an exterior wall. If there is insulation, you should be able to see it around the switch box.

If you find you have no wall insulation, you have taken other conservation actions, and are still cold and uncomfortable, make the following test. In the winter, put a thermometer on a wall between living spaces and one on the inside of an exterior wall. Keep both away from heat sources or cold windows and doors to get true readings. After 20-30 minutes, compare the readings. If there is more than a 7°F difference, you should consider insulating the walls.

Insulation can be blown into the wall cavity through holes drilled from the outside or the inside, using special equipment. Loose-fill rock wool, fiberglass or cellulose can be used. In order for the insulation to be effective, the entire wall cavity should be filled. You may be able to save on labor costs by drilling the holes yourself, having a contractor blow in the insula-

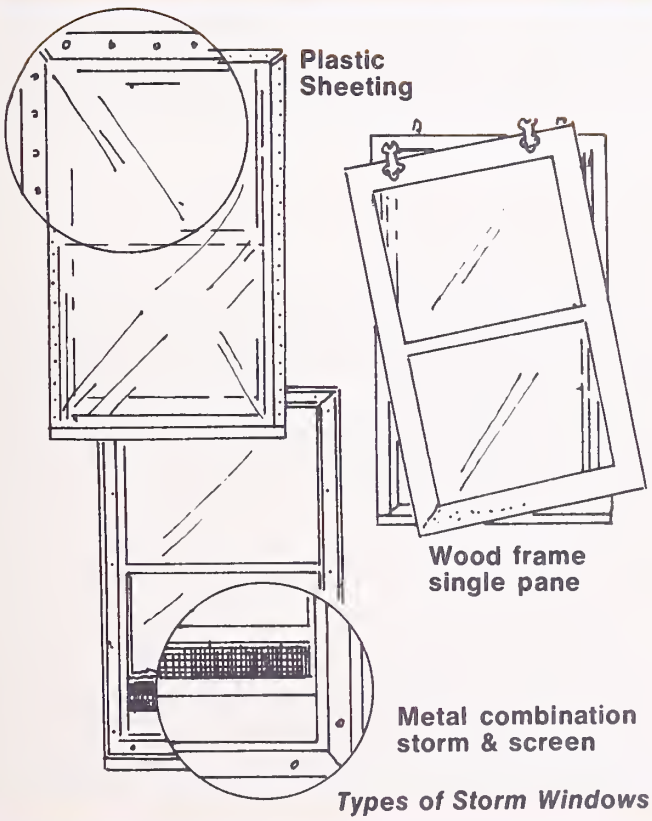
tion, and then patching the holes yourself. This could save a lot of money, and make exterior wall insulation a more attractive option. However, don't attempt this operation if you're not sure how to go about it—leave it in the hands of a qualified insulation contractor.

STORM PANELS AND DOUBLE-GLAZING

Window glass allows a lot of heat to escape. A single pane of glass has an R-value of one. Rather than give up the pleasure of sunlight and a view, windows can be insulated by adding extra panes of glass to create dead air spaces. Each additional layer of glass cuts heat loss in half. Also, storm windows can reduce infiltration losses around prime windows.

Storm Windows and Panels

Storm windows are available in various forms. The least expensive is a piece of heavy plastic sheeting (6 mils) taped around the window frame from the outside or inside of the window or installed on wooden slat frames. Although not as attractive as other varieties, heavy plastic works just as well to stop heat loss. It is especially good for basement windows where appearance is not important and where it can be installed from the inside. CAUTION: Never cover a window used as a fire escape with plastic. It could take too long to remove in case of a fire.



Types of Storm Windows

You can also make or purchase wooden storm windows, or aluminum single or combination screen and storm windows ("triple track"). For many windows of standard size, prefabricated storm windows are available. If your windows are odd sizes, storm windows may have to be custom made for you. There are also do-it-yourself kits available for making single-sash storm windows. A publication on this topic, "Window Insulation: How to Sort Through the Options," is available from DNRC.

MEASURING FOR SIZE

If you are buying ready-made storms, it is critical to measure your windows properly to be sure of getting the right size. Measure from side to side of each frame and from top to bottom (width is quoted first). Tell the retailer exactly where on the frame you measured. A rule of thumb for a double hung window is: the width is the glass width of the primary window plus 4 inches; the length is the length of the glass in both sashes plus 7 inches.

INSTALLATION

Single-sash storms can be applied by attaching them to the top of the primary frame. Since they are usually removed in the summer, they should not be caulked, but should fit tightly and be weatherstripped.

If you want triple tracks installed, you may want to have a contractor do the work because the installation is permanent and rather laborious. Be sure they are caulked on the sides and the top when installed. Do not caulk the bottom or the "weep holes" on the bottom, because they allow condensed moisture to escape and will decrease damage to your windowsill.

Aluminum single or combination storms are available in a variety of price ranges, and the cost, including installation, ranges from $30-$100 per window. It is not necessary to buy the most expensive kind, but when buying storm windows inspect them carefully for the following qualities. An anodized or baked enamel finish is better than a mill finish (plain aluminum) because mill finish tends to corrode. The corners of the frame should be strong and airtight. If you can see through the joints, they will allow air leakage. Make sure the locks and catches work well, and check the depth of the metal tracks at the sides of the window and see whether they are weatherstripped. Be certain the units are not warped and that they have unblocked weep holes. Also make sure the sashes fit tightly where they meet at the center of the windows or there will be air leakage. Since storm windows insulate by creating a dead air space between the panes of glass, there should be little or no air leakage around the storm or through it (which is why they should be caulked and constructed tightly).

Remember, too, that if your primary windows are in poor condition, storm windows will not work as effectively because there will be air leakage through the primary windows. If you cannot recondition or replace them, invest in some weatherstripping or rope caulk.

CONDENSATION

During the winter, you may notice that moisture has condensed on the inside of the storm windows. This is to be expected, and means that they are insulating properly. If too much condensation occurs and water is collecting on the sill instead of draining through the weep holes, the humidity level in your home may be too high. If moisture is condensing on the inside of your primary window, it is a possible sign that your storms are not working effectively. There may be air leakage either from the inside through the prime window or from the outside through the storm window. Attempt to make both windows fit tightly. Further information is available from DNRC in its publication, "Moisture and Home Energy Conservation."

Sliding Glass Doors

Sliding glass doors are especially notorious heat-robbers. It is possible in some cases to provide storm doors or to double glaze sliding doors, but either of these options can be quite expensive. There are two other options, however. One is to ensure that the unit is weatherstripped and locks tightly. The second option is to install heavy or insulated drapes over the door. These drapes should have sand or weights at the bottom so that they form a tight seal and create a dead air space between the drapes and the door.

Storm Doors

Storm doors are essential in Montana; when well-fitted, they provide an airspace between indoor and outdoor air. When purchasing them, use the same standards given above for storm windows. Units should be well constructed, weatherstripped, and caulked so that when installed they will function properly.

WORKING WITH A CONTRACTOR

It is particularly important to select a qualified, reliable contractor. Montana insulation contractors are not licensed according to their skills or qualifications.

Many insulation manufacturers certify installers of their products. If you intend to have insulation installed by a certified installer, make sure the person who actually does the installing has received factory training in correct application procedures.

Get Written Estimates

When beginning your search for a contractor, get names from friends and neighbors who have been satisfied with work done for them. Contact these contractors and get detailed written estimates which should include:

— The types of insulation to be installed and number of packages and bags expected to be used.
— The R-value of the insulation to be installed.
— The total cost of the job and the cost breakdown per square foot of the area to be covered.
— An explanation of the breakdown of all costs, including service charges.

Don't Rely on Product Claims

Ask for references and check them. Also be cautious of claims that may be made, such as that the installation of a particular product will reduce your heating bills by 50 percent, or that your present insulation is "inferior" or highly flammable. Have the contractor verify his savings estimates (how did he determine that you would save that much?). The Federal Trade Commission requires that all such claims must be verifiable. Be sure to inquire also whether the conditions used in the verification procedures are similar to the conditions found in your home. You have a right to be told what sorts of things make savings vary and how those things relate to you. For example, savings depend on installation techniques, weather, heating system efficiency, how weatherized your home already is, and your living patterns. Consider suggesting that a guaranteed savings be incorporated into the contract.

Some insulation contractors claim that their material meets federal standards and is approved by some federal agency. The Federal Trade Commission states that "no federal agency certifies the performance or acceptability of any insulation product." Federal agencies may regulate test procedures and set standards for qualities such as corrosiveness and flammability. They neither recommend one product over another nor certify how well insulation products stop heat loss. Ask to see the label on the insulation package or other documentation to verify that the material that will be used in

your home has been tested for such things as flammability, corrosiveness, and has a stated R-value.

A contractor may say that he represents a utility company. Always check this type of claim directly with the utility company.

Contract Should Be Comprehensive

Once you choose a contractor, be certain that everything that was promised in the estimate is included in the contract. Examine all figures to be sure that R-value, amount of material to be used, and the original prices are correct and clearly written. If there are any changes to be made in the contract, make them before you sign the contract.

PRODUCT CLAIMS

— If any claims are made about the combustibility or settling rates of the material, insist that a guarantee be written into the contract. If a company is certain that its insulation has these outstanding qualities, it should not hesitate to guarantee them.

ADJUSTED COST

— If less than the expected amount of insulation is used, then the cost of the portion not used should be subtracted from the total cost of the job.

WORKMANSHIP

— The contractor should be responsible for workmanship (labor and materials) and damages (to materials and home) caused during installation. Correction of any future damage caused by the insulation (such as electrical wire corrosion) also should be guaranteed in the contract. He should leave the home in the condition in which he found it when beginning the job.

Remember that these provisions should be written in the contract. *Verbal promises are not guarantees.*

Before the contractor begins the job, check the packages and/or cannisters for nationally recognized testing laboratory seals, expiration dates (do not accept an outdated product) and identity of materials being used to make sure they are the ones stipulated in the contract.

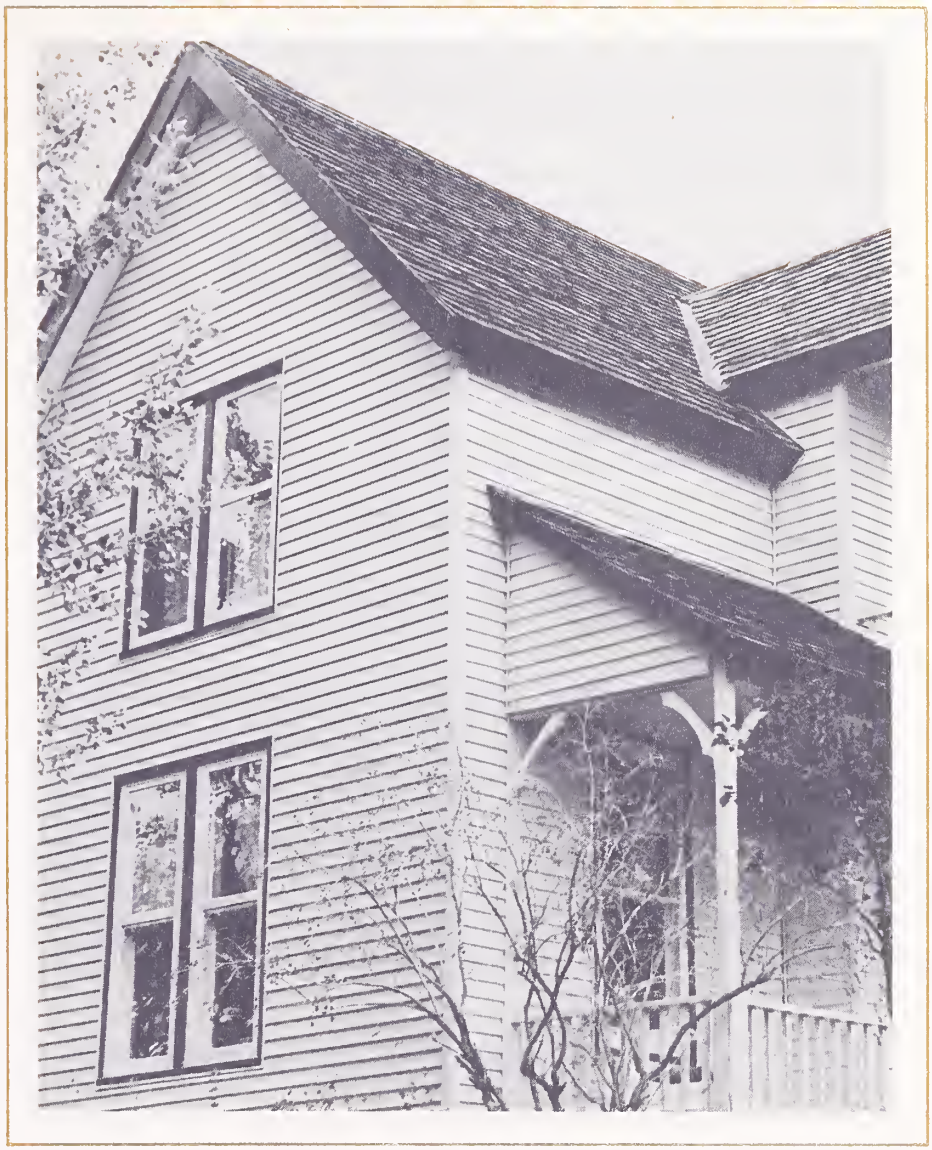
When cellulose is used, watch the contractor emptying the bags. If a powdery residue remains after the bags are emptied, it means the fire resistance has been lessened and it should not be accepted.

It is extremely important to watch the contractor when he installs the insulation. When insulating outside walls, the contractor should drill two holes in every stud cavity and top and bottom above and below windows. Make sure that the contractor routinely drops a weight into these holes before insulation is blown into the walls to check for stops or other obstacles. If there are fire stops, holes must be drilled to insulate fully below and above them.

Some contractors allow the home owner to drill, patch, and paint the stud cavity holes. Although this can save you money, it makes you responsible for ensuring no spaces are missed and walls are returned to original appearance.

CHAPTER THREE

HEATING AND COOLING SYSTEMS



The energy efficiency of your home depends not only on having a tight, well-insulated structure, but also on having a heating or cooling system that operates efficiently. Inefficient systems use more fuel than they

should, and cost more in energy bills. There are several general types of heating and cooling systems and a variety of things that you can do to improve their efficiency and keep them well maintained, as discussed below.

HEATING UNIT TYPES

There are four major kinds of residential heating systems:

- Hydronic (hot water) units generate heat by heating water and pumping it through radiators or baseboard units.
- Steam systems heat a home by converting water into steam, which rises into the radiators.
- Baseboard electric systems use electrical current to heat room air.
- Forced hot air systems heat air and push it through ducts into the home.

A combustion unit that generates hot water or steam is called a boiler, while a system that generates hot air is called a furnace. Some of the three types of systems listed above are designed to burn oil and others burn gas.

HOW YOUR SYSTEM WORKS

An oil- or gas-burning heating system consists of four major parts. The thermostat indicates when the house temperature drops below a set temperature and controls the firing of the furnace or boiler. The distribution system consists of the piping or duct work that carries the hot water, steam, or hot air through the house. The chimney exhausts smoke and gases from the boiler or furnace. The fourth component is the boiler or furnace itself, which consists of three main parts: the burner, the combustion chamber, and the heat exchanger.

In a gas-fired system, the burner consists of a series of tubes with small holes (orifices) much like the burners on your gas kitchen stove. Oil-fired burners use a nozzle with perforations that can be adjusted to improve efficiency. The combustion chamber surrounds the burner in these systems. The heat exchanger is where heat is transferred to air or water. When the burners raise the temperature of air or water in the combustion chamber, the fan or water pump starts circulating warm air or water throughout the house. Baseboard electric systems generate heat by passing electric current through resistance wires.

HEATING UNIT MAINTENANCE

Some maintenance steps described here are only for gas units, and others are only for oil units, but the various types of systems have many maintenance requirements in common, as follows.

HOT AIR SYSTEMS

First, check your ducts for leaks, and seal them with duct tape. Notify your heating contractor on his next visit.

Next, inspect your air filters monthly. This is important and easy to do. Check the manufacturer's specifications on your furnace's filter system, since some furnaces come equipped with temporary or disposable filters, while others have permanent filters that need to be washed.

Check the manufacturer's specifications concerning the proper maintenance procedures for your blower motor.

Finally, keep all registers clean by vacuuming them every few weeks.

HOT WATER SYSTEMS

If you have a hot water system, there may be air in the system. If your radiators do not get hot or only a portion of the radiator gets hot, you will have to bleed air from the system. There is usually a small valve at the top of each radiator. Open the valve of each radiator, place a bucket under it and keep it open until water comes out. Be careful because the water is hot. Also check the manufacturer's instructions on lubricating the circulator pump.

STEAM SYSTEMS

A one-pipe steam system is, typically, an oil-fired boiler that sends steam from heated water into a single pipe to room radiators. When the steam cools and condenses, the condensate is returned to the boiler via the same pipe. In a two-pipe system, separate pipes are used for steam and condensate.

In one-pipe steam systems, if a radiator does not get hot, there may be a problem with the venting valve located on the side of the radiator. Close the shutoff valve and remove the venting valve. Replace the valve or clean the old one in a solution of vinegar and boiling water.

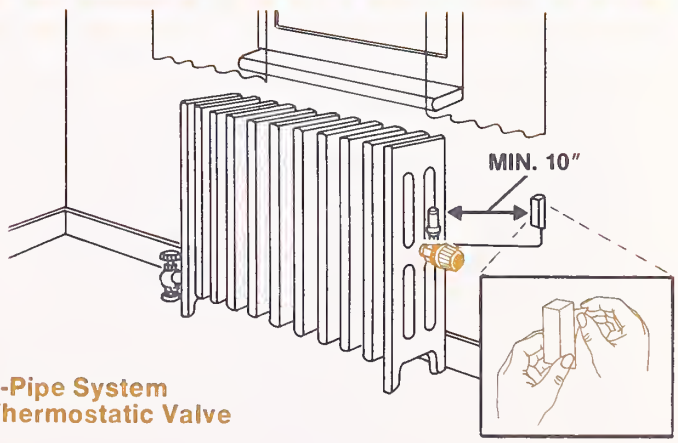
For any steam system, remove one bucket of water from the base of the boiler weekly. This will remove sediment that forms an insulation barrier between the burner and the boiler water. If the boiler water is very dirty, the entire system may have to be cleaned by a professional heating contractor. Clean water in a steam heating system is a definite energy saver, because it boils quicker than dirty water.

AUTOMATIC CONTROL VALVES

Another one-pipe steam problem is chronic overheating or wide temperature swings in one or more rooms. This wastes energy and costs you money. One product designed to improve the efficiency of one-pipe systems is a thermostatic radiator valve that requires no electrical wiring or parts.

In a one-pipe system every radiator must have its own air vent installed so that the air that collects in the radiator during the off cycle of the boiler can be vented to allow incoming steam to circulate properly in the radiator.

Fluctuating room temperature around the thermostatic radiator valve's operator-sensor affects the air venting through the individual radiator or connector. When the sensor calls for heat, the steam enters the radiator and pushes the air through the valve and out the vent. At the same time, any condensate that has collected in the radiator passes through the valve in a direction opposite to the steam via the one pipe that carries it back to the boiler. When the setting temperature is reached, the valve is closed and no venting takes place.



1-Pipe System
Thermostatic Valve

Typical replacement of existing air vent from radiator and installation of thermostatic valve with heat sensor. Radiator is uncovered and pitched toward supply valve. Sensor (inset) mounted to wall not less than 10" from thermostatic valve with peel off adhesive backing or screws. Sensor must be mounted 2 feet away if radiator is covered by drapes or a cabinet.

These thermostatic valves also make it possible to set the thermostat at different temperatures in different parts of the house. These valves can save large amounts in oil or gas heating costs over the life of the heating system.

The typical thermostatic valve retails for between $30 and $80 and can be used in all heating systems, new or old, regardless of whether you are using oil, gas, or coal. They can be installed in one- and two-pipe steam systems, two-pipe hot water radiator, baseboard, and convector systems.

GAS-FIRED HEATING UNIT MAINTENANCE

Gas units require very little maintenance. However, there are several important steps to follow. Have the burner cleaned every 2 or 3 years. This is particularly important if you have a boiler. Although gas units do not degrade, you might want to have the efficiency tested once to see whether the unit was originally installed at its highest efficiency. A service technician should also check the following:

— The operation of the gas valve, regulator, and safety control
— If the primary air supply shutter is set properly
— If the thermostat controls are clean and operating properly.

There are several maintenance steps home owners should follow. Periodically check the burner to see whether the unit is firing correctly. Are all orifices firing? If there is any problem, notify your heating contractor or utility.

Gas furnaces have an internal limit control that senses temperatures and controls when the circulating fan goes on and off. When your unit turns off, there is still a substantial amount of heat remaining in the unit. If you lower the internal limit control 5 degrees to the range 100°F to 110°F, the fan will stay on longer and send the heat that normally stays in the heating unit to the rest of the house.

OIL-FIRED HEATING UNIT MAINTENANCE

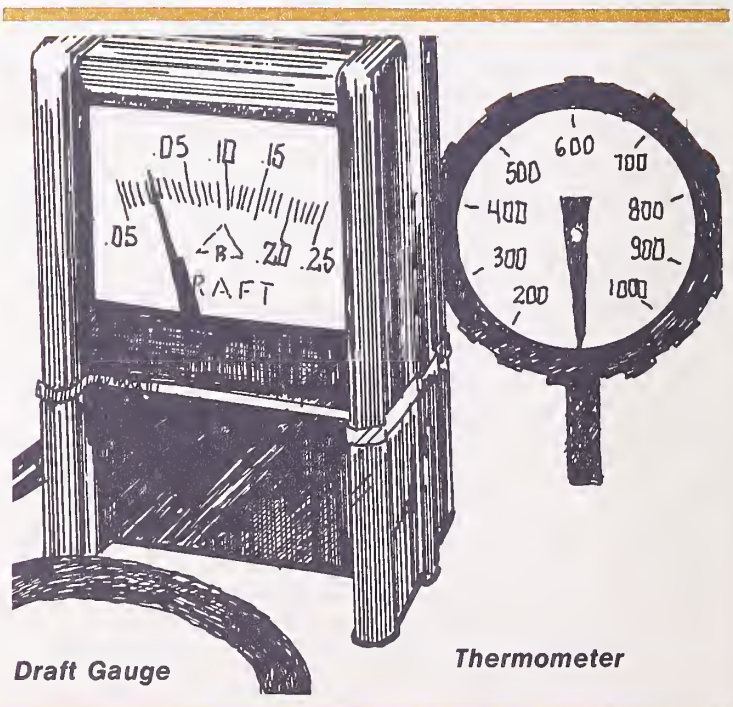
There are three important things you can do to your oil-fired heating system:

— Have an annual combustion efficiency test.
— Have it cleaned annually.
— Replace when necessary.

COMBUSTION EFFICIENCY TESTS

All oil burners should be tested for efficiency annually because the efficiency with which they burn oil degrades over the course of the year. To have this test done, contact your local heating contractor.

First, the heating contractor will measure the net stack temperature by placing a thermometer in the chimney. High stack temperatures signify improper draft or a dirty heat exchanger.



Draft Gauge *Thermometer*

Second, the contractor will measure the draft in the stack and over the fire. This will indicate whether there is too much or too little pull of air in the unit to get combustion gases into the chimney. Too much draft will cause the oil to be blown through the burner. Since the oil cannot be properly burned, oily soot will form in the combustion chamber and chimney. Too little draft will cause smoking.

Third, smoke from the chimney will be evaluated to determine how efficiently the oil is being burned.

Once these other tests have been completed and any problems corrected, the serviceman will test the flue gas to determine how much air is in the flue gas. This will indicate how completely the fuel is being burned.

When these tests are taken, the unit's overall efficiency can be determined. Efficiency tests are vital because every increase of 5 percent in efficiency lowers your fuel bill by 6½ percent.

CONTRACTOR MAINTENANCE

Once the efficiency test has been completed, the heating contractor should perform a series of maintenance steps:

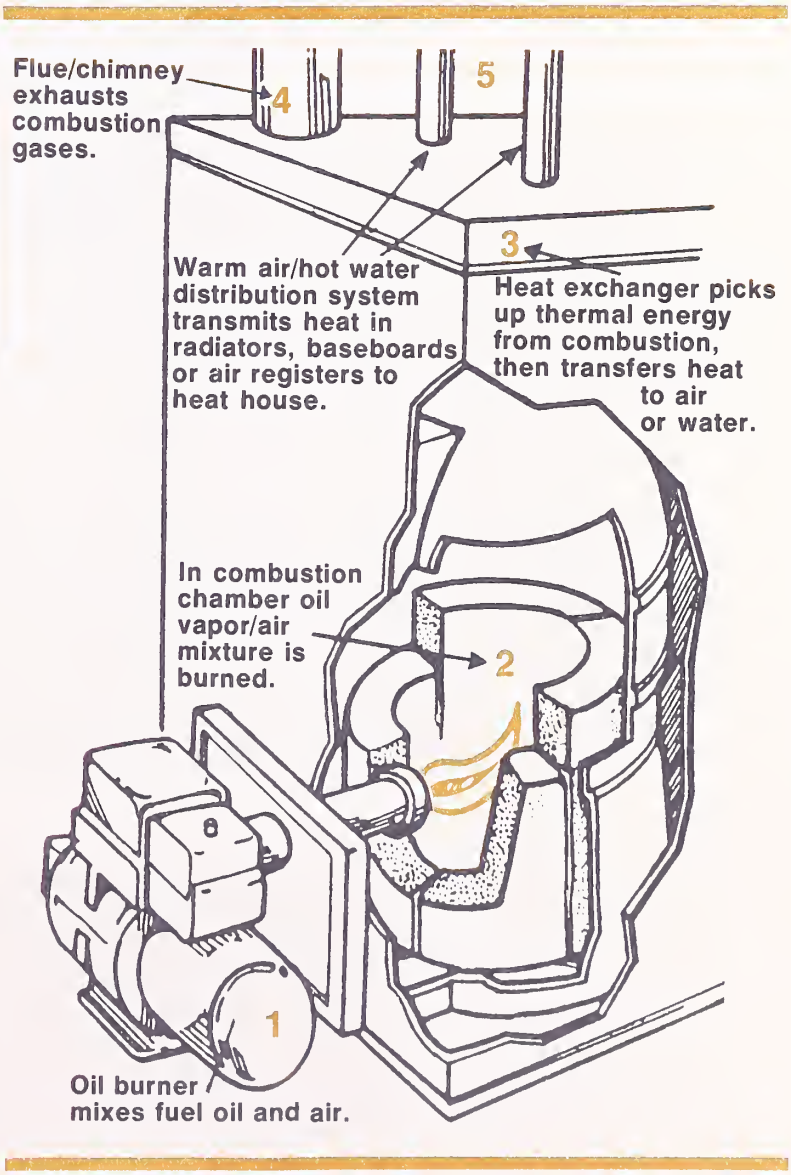
- Adjust and clean the burner unit.
- Remove soot from combustion chamber and heat exchanger (using a wire brush, vacuum, or chemical cleaner).
- Adjust the fuel-to-air ratio for maximum efficiency.
- Check electrical connections, especially those on safety devices.
- Adjust the draft regulator and dampers.
- Change the oil filters.
- Change the air filters.
- Check the oil burner nozzle, clean, and replace if necessary.
- Check the oil pump.
- Clean and adjust the house thermostat.
- Check for sources of air leakage into the furnace. This can be done by using a candle and observing those points at which the flame is pulled by the furnace draft. All sources of leakage should be sealed with a good grade of furnace cement.

If you have a hot water system, the service technician should also check the following:

- The water pump
- The operation of the flow control valve
- Piping leaks
- The operation of radiator valves.

If you have a hot air system, your heating contractor should check the following:

- The blower motor; if it does not have a sealed bearing, the blower motor should be oiled
- The duct system should be checked for leaks.


Flue/chimney exhausts combustion gases.
4
5
3
Warm air/hot water distribution system transmits heat in radiators, baseboards or air registers to heat house.
Heat exchanger picks up thermal energy from combustion, then transfers heat to air or water.
In combustion chamber oil vapor/air mixture is burned.
2
1
Oil burner mixes fuel oil and air.

LYNN EFFICIENCY CHART FOR NO. 2 FUEL OIL

NET STACK TEMP. (degrees F.)

PERCENT OXYGEN	300°	350°	400°	450°	500°	550°	600°	650°	700°	750°	800°	850°	900°
15	75½	72½	69½	66¼	63	60	56¾	53½	50¼	47	43½	40¼	36¾
14	77¼	74½	72¾	70	68	64¼	61½	58¾	55¾	52¾	49¼	47¼	44½
13	79¾	77¼	75	72½	70	67¾	65¼	62¾	60¼	57½	55	52½	50
12	80¾	78½	76¾	74¾	72½	70¼	68¼	66	63¾	61½	59	56¾	54¼
11	82¼	80¼	78½	76½	74½	72½	70½	68½	65¾	64¼	62¼	60	58
10	83	81	79¾	77¾	76	74¼	72½	70¾	68¾	67	64¾	63	61
9	84	82¼	80¾	79	77¼	75¾	74	72¼	70¾	68¾	67	65¼	63½
8	84¾	83	81¾	80¼	78½	77	75½	73¾	72¼	70½	69	67½	65¾
7	85½	83¾	82½	80¾	79¼	77¾	76¼	74¾	73¼	71½	70	68½	67
6	85¾	84½	83	81½	80¼	78¾	77¼	75¾	74½	73	71½	70	68½
5	86	85	83¾	82¼	81	79½	78¼	77	75½	74	72½	71¼	70
4	86½	85¼	84	83	81½	80¼	79	77¾	76½	75¼	73½	72¾	71
3	87	85¾	84½	83½	82¼	81	79¾	78½	77¼	76	74¾	73¾	72
2	87¼	86	84¾	83¾	82¾	81½	80¼	79	78	76¾	75½	74½	73
1	87½	86½	85	84¼	83¼	82	81	79½	78¾	77½	76¼	75¼	74

OXYGEN MEASUREMENTS

LYNN EFFICIENCY CHART FOR NO. 2 FUEL OIL

NET STACK TEMP. (degrees F.)

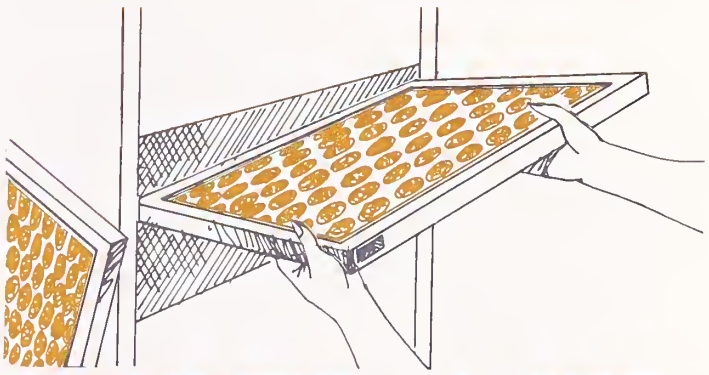
% CO_2	350°	400°	450°	500°	550°	600°	650°	700°	750°	800°	850°	900°
15	87½	86½	85¼	84¼	83¼	82	81	79¾	78¾	77½	76½	75½	74¼
	87½	86¼	85	84	83	81¾	80¾	79¼	78½	77¼	76	75	73¾
14	87¼	86	84¾	83¾	82¾	81½	80¼	79	78	76¾	75½	74½	73
	87	85¾	84½	83½	82½	81¼	80	78¾	77½	76¼	75¼	74	72¼
13	86¾	85½	84¼	83¼	82	80¾	79½	78¼	77	75¾	74½	73½	71¾
	86½	85¼	84	83	81½	30¼	79	77¾	76½	75¼	73¾	72¾	71
12	86¼	85	83¾	82½	81¼	79¾	78½	77¼	75¾	74½	73	71½	70¼
	86	84¾	83½	82	80¾	79¼	78	76½	75¼	73¾	72¼	70¾	69½
11	85¾	84½	83	81½	80¼	78¾	77¼	75¾	74½	73	71½	70	68½
	85½	84	82½	81	79½	78	76½	75	73¾	72	70½	69	67½
10	85	83½	82	80½	78¾	77¼	75¾	74¼	72¾	71	69½	68	66¼
	84½	83	81½	79¾	78	76½	75	73¼	71¾	70	68¼	66¾	65
9	84	82¼	80¾	79	77¼	75¾	74	72¼	70¾	68¾	67	65¼	63½
	83½	81¾	80	78¼	76½	74¾	73	71¼	69½	67½	65½	63¾	62
8	83	81	79¼	77½	75½	73¼	71¾	70	68	66	64	62	60
	82¼	80¼	78½	76½	74½	72½	70½	68½	66½	64¼	62¼	60	58
7	81½	79½	77¼	75¼	73¼	71	69	67	64¾	62½	60¼	57¾	55½
	80¾	78½	76¼	74	71¾	69½	67¼	65	62¾	60¼	57¾	55½	53
6	79¾	77¼	75	72½	70	67¾	65¼	62¾	60¼	57½	55	52½	50
	78½	76	73½	71	68	65½	63	60¼	57½	54½	51¾	49	46½
5	77¼	74½	71¾	69	65¾	63	60	57	54	51	48	45½	42¼
	75½	72½	69½	66¼	63	60	56¾	53½	50¼	47	43½	40¼	36¾
4	73¼	69¾	66¼	62¾	59¼	55¾	52	48½	45	41¼	37½	33¾	30

ELECTRIC HEATING UNIT MAINTENANCE

Electric heating units have few maintenance problems.

There are three parts of an electric hot air furnace that deserve attention: the fan, the thermostat, and the air filter. The fan is the major source of air circulation in a furnace, so it is essential that it perform efficiently. To ensure this, the fan blades and motor should be kept clean. A good maintenance schedule will include checking and cleaning these components several times during the heating season. Like oil and gas systems, electric units should have their air filters cleaned on a regular basis. These are usually located near the circulating fan and can simply be removed and cleaned or replaced. This should be done monthly. Finally, do not neglect to have your thermostat cleaned and checked periodically.

Baseboard electric heating units should be vacuumed frequently.



HEAT PUMPS

A heat pump is a device that extracts heat from the outside air or from groundwater and pumps that heat into your home. Heat pumps use refrigerants, much like an air conditioner operating in reverse, to extract the heat from relatively cool air and groundwater. This extracted heat boils the refrigerants, which are then compressed. The compression process increases the temperature of the gas, which then gives up its heat to your living area.

Air and groundwater heat pumps have been used in Montana, with mixed results. Heat pumps that extract energy from the outside air work poorly when the temperature drops much below 45°F. That rules them out for most of the winter months in Montana. Groundwater heat pumps depend on the constant temperature of subsurface water, which varies little during the year. However, a groundwater heat pump can be very expensive to purchase and install—be sure to investigate other options such as high efficiency gas furnaces and additional insulation before you go this route.

To learn more about heat pumps, request a copy of "Using the Earth to Heat and Cool Homes," available free from DNRC, or read the article in the October 1985 issue of *Consumer Reports*.

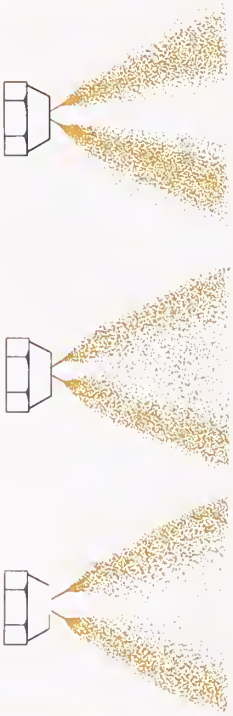
OIL BURNER RETROFITS

If you cannot achieve at least 72 percent efficiency after your contractor has serviced your oil burner, you may want to explore ways to upgrade your heating system. There are several retrofit options: optimizing your burner firing rate, installing a flame retention head burner, installing a hot water heater, or as a last step, installing a more efficient boiler or furnace.

1. Optimizing the Burner Firing Rate. When a heating unit is initially installed, it is "sized" to provide a sufficient amount of heat for the home, given its requirements as determined by the degree of insulation, tightness, use of storm windows, space to be heated, and so on. The heat output of an oil burner is matched to the requirements of a house in part by installing the proper nozzle. This nozzle determines the rate at which oil flows into the burner.

For best efficiency, your oil dealer or heating contractor should adjust the burner nozzle during the annual maintenance visit. This simple retrofit can save up to 7 percent of your fuel costs and is especially important if you have added insulation or tightened your house.

Nozzle Types



Your oil burner nozzle determines:
1. **the flow rate of the oil,**
2. **the spray angle of the oil, and**
3. **the spray pattern of the oil**

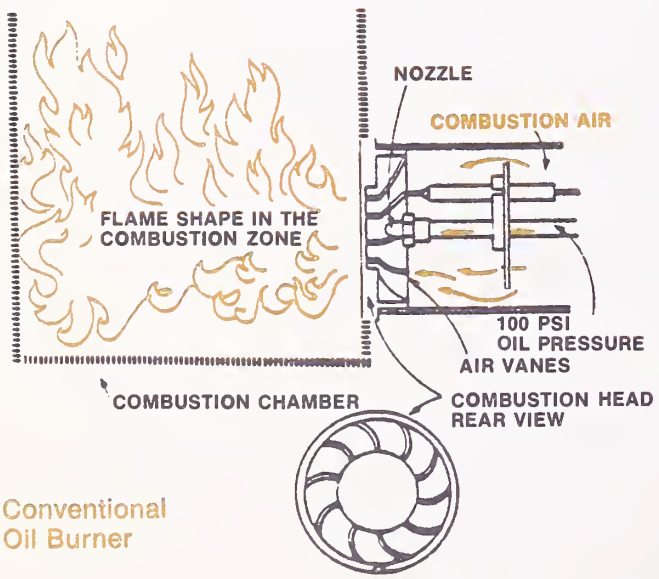
for your individual furnace or boiler.

2. Installing a High-Speed Flame Retention Head Burner. A high-speed flame retention head burner is one of the most recent technological innovations on the market. This burner atomizes the oil more efficiently than conventional burners, allowing a hotter flame and a higher efficiency.

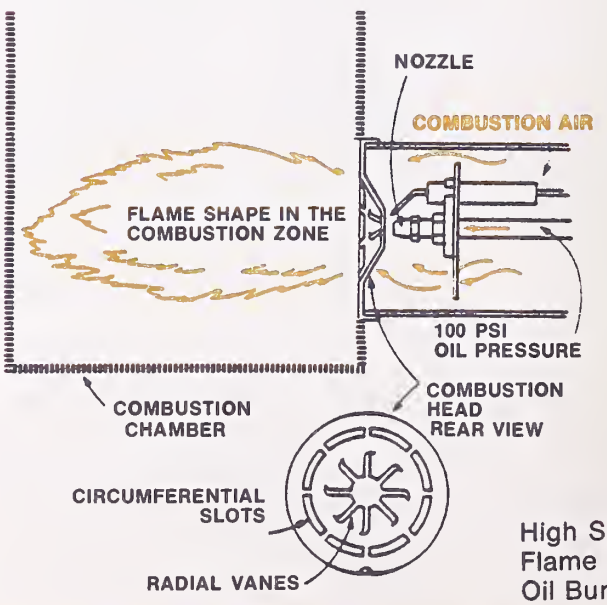
3. Installing a New Oil Boiler or Furnace. If your boiler or furnace cannot be sufficiently upgraded, it is advisable to replace it. When buying a new boiler or furnace, there are several points to keep in mind. First, make sure it comes equipped with a high speed flame retention head burner. If you have a boiler, purchase a "wet base" unit. The combustion chambers in these are surrounded by water and are very efficient. Recent studies show that wet base heating units have the highest combustion efficiency of any oil burner on the market.

OIL/GAS COMBINATION BURNER

If you have both oil and gas capability in your home, it is now possible to retrofit dual fuel flame retention head burners on an existing single fuel boiler system. A manual switch converts the system from gas to oil. The new flame retention head produces the same torch-like flame with either fuel.



Conventional Oil Burner



High Speed Flame Retention Oil Burner

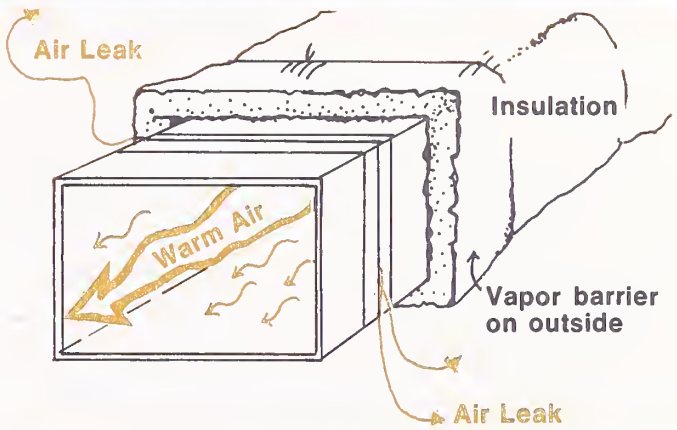
OTHER HEATING UNIT MODIFICATIONS

Insulating Hot Water Pipes and Duct Work

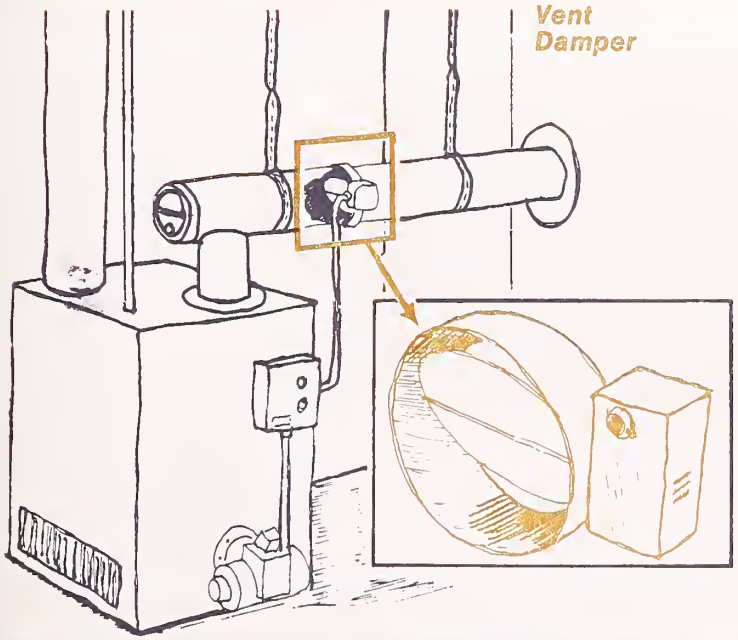
Any heat pipes or ducts in exposed areas (unheated basements, garages, or crawl spaces), should be insulated. Energy is lost when heat is transmitted from the heating unit to the house through uninsulated pipes or ducts.

To insulate your duct work, buy special duct wrap insulation or batt or blanket insulation and wrap it around the ducts, securing it with duct tape. Be sure that you are insulating to at least R-7. Place the vapor barrier on the outside of the insulation, and butt the ends of the insulation snugly together with duct tape.

Hot water pipes can be insulated with pipe insulating tape. Simply wrap this tape around the pipes in any exposed areas. Be sure, before adding pipe or duct insulation, that you have checked for leaks in the piping or for holes in the ducts. Use boiler putty or duct tape to seal any leaks or holes in the ducts before covering the ducts with insulation. Either of these problems will significantly reduce the benefit of the added insulation.



Vent Dampers



A retrofit option that has recently received a lot of attention is the vent damper. This device is designed to reduce "off cycle" heat loss. Off cycle heat loss is the process by which the natural draft of the chimney pulls the heated air through the unit and up the chimney after the unit has shut down; the process robs the house of heat. A vent damper is placed in the pipe between the heating unit and the chimney to block the passage of heat after the unit has shut down.

There are two types of vent dampers available; electromechanical, for use in both oil and gas units, and thermomechanical, for use in gas units only. The electromechanical vent damper is electrically coupled with the thermostat on oil units and the gas valve on gas units. It opens when the thermostat signals that the heating unit is on and closes when the thermostat signals the unit is off. These have fail-safe mechanisms to prevent them from locking in the closed position.

A thermomechanical damper has no electrically activated parts. It consists of bimetallic fingers that extend into the vent pipe. When the

heating unit fires, the hot gases cause these fingers to open. After the unit shuts down, these fingers close and block the flow of heat.

The energy savings potential of vent dampers depends on four things:

— The type of heating unit
— The firing rate of the heating unit
— The size of the chimney and
— The location of the heating unit.

Boilers are most adaptable for the installation of a vent damper. Because it uses water as a heating medium, a boiler has a high thermal capacity which means it has more heat to lose in its off cycle.

When your heating system was installed, its proper heating capacity was determined on the heat requirements of your house at the time. If, since installing the unit or buying your house, you have added insulation, storm doors and windows, or caulked your home, your heating facilities may now be too large. If this is the case, your system is generating more heat than you can use, and excess heat is being exhausted up the chimney.

Draft also creates a problem if your chimney is too large. Too big a chimney will draw heat out of the unit faster during the off cycle than a chimney of the right size.

Heating units located in heated portions of the home also contribute to heat loss by pulling heated air up the chimney. The air that escapes is replaced by colder air entering the home from outside. The colder air must be heated which causes the heat system to work more.

The relative usefulness of a vent damper in fighting these problems is open to question. Early studies claimed that vent dampers could reduce fuel consumption by as much as 24 percent. However, current studies by Arthur D. Little and Brookhaven National Laboratory have indicated that savings can range from 2 percent to 11 percent. Brookhaven's study further indicated that if the heating unit is retrofitted with a high speed flame retention burner, only 2 to 3 percent additional savings are available from the installation of a vent damper.

Generally, it appears more cost effective to increase the combustion efficiency of a unit than to install a vent damper. A vent damper can be used to improve efficiency in cases where no other measures are possible, though improper installation of a vent damper may be hazardous. For this reason it must be installed by a qualified and experienced gas or oil heating specialist. Vent dampers should be inspected every year.

Best Payback Ranking of Refit Devices

The following refit options are generally accepted as energy savers, according to Brookhaven National Laboratory which evaluated them on 250 homes in the NJ-NY area between October 1979 and October 1981.

Option	Typical Fuel Savings %	Option Cost $	Payback Time in Months Small House	Payback Time in Months Large House
BOILERS				
Double-Setback Thermostat	11	80	9	9
Double-Setback Thermostat+ Boiler Temperature Programmer*[3]	19	395	19	11.5
Retention Head Burner[1] (high speed flame retention type with optimized firing rate)[2]	18	410	21	10
Retention Head Burner[1] (3,450 rpm) only.	12	325	25	13
Retention Head Burner[1] with Optimized firing rate[2] + Boiler Temperature Programmer	21	678	30	15
Vent Damper	9	295	30	15
Retention Head Burner[1] with Optimized firing rate[2] + Vent Damper	20	703	32	16
Flue Heat Exchanger	10	520	48	24
FURNACES				
Retention Head Burner[1] (high speed flame retention type with optimized firing rate)[2]	11	410	34	17
Retention Head Burner[1] (high speed flame retention type with optimized firing rate)[2] + Vent Damper	11	703	59	29

*Installed in houses *un*occupied during the day.

Chart based on: 1. oil @ $1.30/gal., 2. small house = single heating zone consuming 1,000 gals/yr., 3. large house = 2 heating zones consuming 2,000 gals/yr.

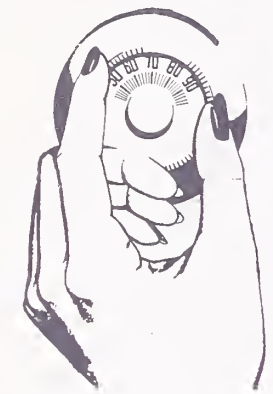
[1]Combustion chambers repaired or relined as necessary before installation of retention head burner.

[2]Heat exchangers mechanically cleaned.

[3]A boiler temperature programmer senses the outside air temperature and a control device adjusts boiler water temperature to meet the required heating loads at times set by the homeowner to maintain high temperature levels.

Thermostat Setback and Automatic Thermostats

One of the simplest ways to reduce heating bills is to lower the thermostat setting so that the heating unit runs less. Try lowering the setting permanently to 68°F and lowering it even further to 60°F at night or when no one is home. (Infants and sick or elderly people need higher settings.)



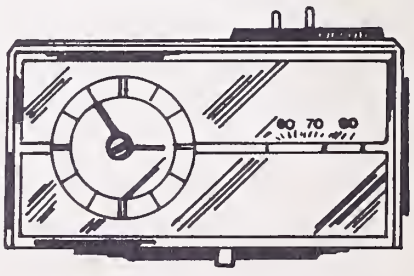
Manual thermostat

These nighttime thermostat adjustments can be made manually with the thermostat you now have, but this has disadvantages. Not only would you have to remember to set and reset the thermostat each day, you would also wake up to a cool house, and be uncomfortable until the furnace provided enough heat. Automatic (or clock) thermostats are available to change temperature settings automatically. They can be used to turn down the heat at night and turn it up again the following morning before you get up. Some of these thermostats can control both heat and air conditioning, and offer the potential for year-round savings. The period each day during which the heat or cooling is reduced is called the "setback period." Various thermostats differ in the setback periods they allow. Minimum periods range from 30 minutes to 4.5 hours; maximum periods range from 11.5 to 23.5 hours. Automatic thermostats are also available which allow two or more setback periods, such as after you go to bed and again after you leave for work. For example, before you wake up, the temperature would be raised automatically. After you leave it would be lowered, but it would rise again before you return. After you go to bed, it would be lowered again.

When purchasing a clock thermostat, be certain that the model you buy is compatible with the electrical wiring in your present thermostat. Conventional thermostats have two electrical connections, but some of the clock thermostats have more. So check to make sure. Also make sure that the setback period is the duration that you desire.

Before you install your clock thermostat, make sure it will be installed away from abnormally heated areas like radiators and fireplaces, and abnormally cold areas like cold exterior walls and drafty areas.

The savings available from thermostat setback are easy to calculate. The rule for Montana conditions is that permanent lowering of the thermostat setting saves 3 percent on your fuel bill for every degree you lower the setting. An additional 1 percent savings is achieved for each additional degree you lower the setting for an 8-hour period, such as at night or while you're at work. Thus, if you usually keep your thermostat at 72°F and you lower it to 68°F throughout the day, your fuel bill will be reduced by 12 percent. Lowering it even further at night will produce additional savings. The reason for the savings is that the greater the temperature difference between the inside and the outside, the faster heat flows toward the colder temperature. If you lower that temperature difference by lowering the thermostat setting, the rate of heat loss is lowered and your furnace doesn't have to work as hard to replace lost heat.



Automatic clock thermostat

For a conventional unit, it is not true that it takes more fuel to reheat the house than you saved, as long as the setback period is at least 4 hours.

Note: Owners of electric heat pumps may find it is not advisable to use thermostat setback as a conservation step. With a heat pump, it can take more energy to bring the house up to the desired temperature than would be saved.

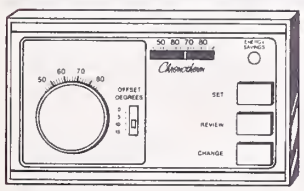
Programmable Microelectric Controllers

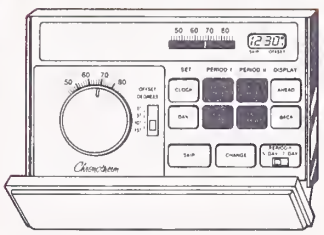
The newest strategy in residential energy management is based on microprocessors and thermistor sensors, most of which are compatible with conventional residential electric supply and wiring.

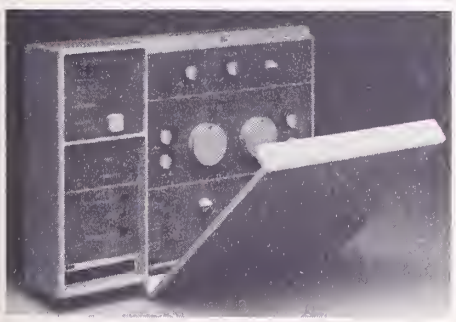
Considering what functions these new home energy managers control, they are surprisingly price competitive with automatic thermostats—in the $100 to $150 range. The home owner usually can install these with a screwdriver.

Most new microelectrics perform one or more of the following energy control functions at the press of a button:

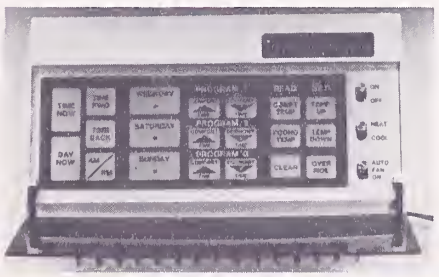
- — Accepts multiple different daily settings which they can remember and repeat (thanks to the microprocessor). These settings can be overridden manually without affecting the rest of the daily or weekly program.
- — Allows six or more temperature settings a day, usually ranging from 54° upwards.
- — Makes heating or air-conditioning systems responsive to outside temperature changes.







Typical microelectric programmable thermostats to control both central heating and central air-conditioning. Easy to install and replaces manual and simple automatic thermostats at moderate extra cost. Some well known manufacturers are: American Stablis, Autotronics, Honeywell, Johnson Controls and PSG Industries, among others.



More costly programmable thermostat consists of the wall mounted programmer, the indoor and the outdoor temperature sensors connected by wires to the programmer.

Most microelectric controllers have a liquid crystal display for time of day and house temperature. Some even have a back-up battery power pack that takes over automatically in the event of a power failure.

The objective of any thermostat is to increase furnace efficiency by regulating its on-off cycle. The new programmables "learn" and "remember" your living patterns and slow down the wasteful cycling of the heating/cooling system when it is not needed; overnight, on weekends, or when no one is home. By keeping the highest temperature up for, say, 4 or 5 hours a day instead of 16 hours a day, these microelectrics can pay for themselves very quickly.

AIR-CONDITIONING SYSTEMS

There are several types of air-conditioning systems for cooling your home during hot summer months. You can select from a wide range of window/wall units, central systems, or heat pumps. All of these systems require maintenance to keep them operating at peak efficiency.

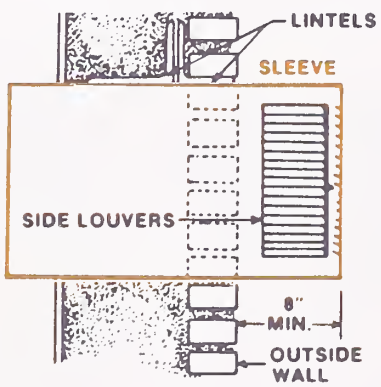
Once you have purchased and installed your air-conditioning system, it will require annual servicing. Before the beginning of each cooling season, the air filters, evaporator coil, condenser, and fan motor should be cleaned. Home owners generally can clean the air filters, but a serviceman should clean the condenser, evaporator coil, and fan motor.

Room Air Conditioners

INSTALLATION

The window units fit in an open window. Wall units are placed through a hole in the wall. These units are relatively small and normally cool only one room.

A poorly or improperly installed through-the-wall air conditioning unit wastes energy even in the fall and winter months by allowing drafts to infiltrate the home.



Side view of a thru-the-wall air-condition unit. Note the use of lintels to support wall material and how unit's side louvers are unobstructed for maximum air flow.

When buying an air conditioner, it is crucial to get the right size. A good rule of thumb is that you will need 25 to 30 Btus for each square foot of space you want to air condition. If your house or the room where you plan to install the unit is poorly insulated or has many windows with a southern exposure, you will need a higher Btu unit. If your air conditioner is too small, it will run constantly on hot days and still not be able to cool the room. On the other hand, if your unit is too large, it will cool the area so quickly that it will have to turn on and off more often to control the temperature of the room. A large amount of electricity is needed to start the unit and bring it up to normal operation, so the more often the compressor has to start, the more electricity will be wasted.

MAINTENANCE

In a room unit, the filter is located behind the front grill or panel. The panel usually is held in place by several spring clips that permit the panel to be popped off. Once the front is removed, you can remove and clean the air filter. If the filter is especially dirty or torn, replacement kits can be purchased in most hardware stores. Be certain to replace the filter with one that is of equal thickness. A thicker filter will reduce the air flow and lessen the unit's efficiency.

At the end of the cooling season, remove and store your room air conditioner. If you have a wall unit that cannot be removed, be sure to cover and seal the unit each winter. Seal all leaks around the unit with tape, and cover the condenser sections with plastic. This will restrict the flow of air through the unit and protect the unit from winter weather. *Do not* stuff fiberglass or rock wool around the unit. Fiberglass and rock wool fibers may enter your living area, and can cause respiratory problems or skin irritation.

Central Air Conditioners

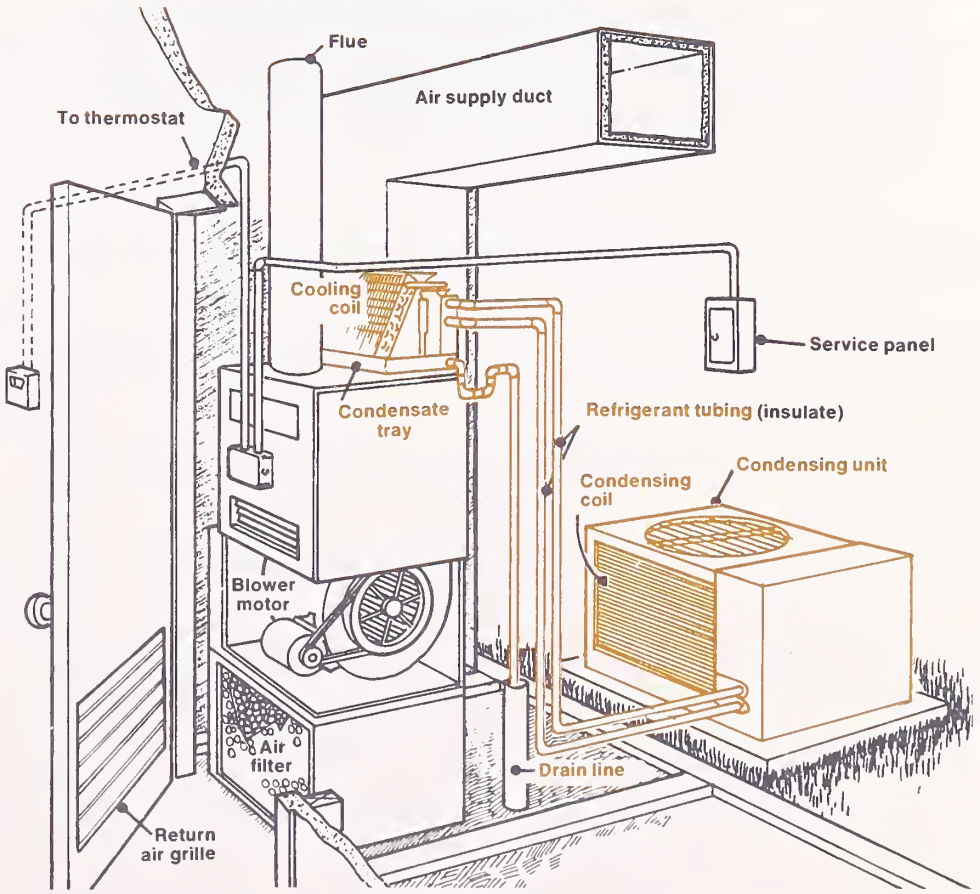
INSTALLATION

Determining the correct size central air-conditioning system can be complicated and should be done only after careful consultation with one or more professional cooling contractors. Sizing by "rule of thumb" can be misleading and could result in purchase of the wrong size system.

The size of a central air conditioner should be based on "heat gain" calculations. The method of calculation is standardized and reliable to within ±5% of the capacity required for cooling and humidity reduction.

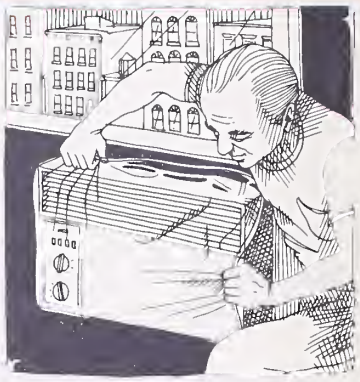
Once you have purchased the unit, it is important to select a good location for installation. It is important that the condenser (the part of the unit that extends outside the house) has good air circulation around it. If you don't have good air circulation around the condenser, the heat cannot be carried away, and the efficiency of the unit will be reduced. Also, try not to place the condenser in direct sunlight. The sunlight heats the condenser, reducing the ability of the unit to disperse the heat from the house. If you must place an air conditioner in direct sunlight, provide some sort of shading that does not interfere with air circulation.

Major Components of a Central Air-Conditioning System



MAINTENANCE

Many manufacturers of central air conditioners advise against enclosing the outdoor condenser at the end of the cooling season. Elimination of moisture is important to the unit's life and performance, and nothing should inhibit its year-round ventilation.



CHAPTER FOUR

NEW HIGH EFFICIENCY HEATING SYSTEMS

New high efficiency residential heating systems can convert up to 95 cents of every fuel dollar to usable heat. These new systems cost more than standard furnaces, but normally will pay back their higher initial cost

in less than 5 years. Some systems will pay back in 2½ years.

Before we examine these new high efficiency furnaces and boilers, it is important to understand that you can get the most out of them—or your present heating equipment—only if your house is properly sealed. Your energy dollar should be spent first on the building envelope: caulking, weatherstripping, and insulating.

If you decide on a new high efficiency heating system, you'll need the guidance and advice of a professional heating contractor.

OPERATING PRINCIPLES OF THE NEW HIGH EFFICIENCY HEATING SYSTEMS

Several new models of gas furnaces and boilers extract so much heat from combustion gases that the gases are cool enough to be vented outdoors through a 2-inch diameter PVC pipe. This technological breakthrough does away with the need for a chimney and a vent damper, and has tremendous cost- and space-saving implications for new construction.

Recuperative/Condensing Furnaces

These new high efficiency furnaces recover most of the heat from the flue gas. They extract so much heat that the water vapor in the gas condenses—that's why they are also called condensing furnaces.

In a conventional furnace, when the thermostat calls for heat, the furnace's burner ignites and the hot gases go up through the heat exchanger, heating air which then is ducted to living space. The combustion gases leave the heat exchanger and go up the chimney at temperatures around 400°F and higher.

The new recuperative/condensing furnaces capture much of this wasted heat in a variety of ways. No matter what the method, the new recuperative/condensing furnaces efficiently capture more heat, resulting in low stack temperatures. For example, one furnace has a stack temperature between 105°F to 115°F. These low temperatures eliminate the need for a chimney. Cool combustion gas is vented directly to the outside through plastic pipe, as with a clothes dryer.

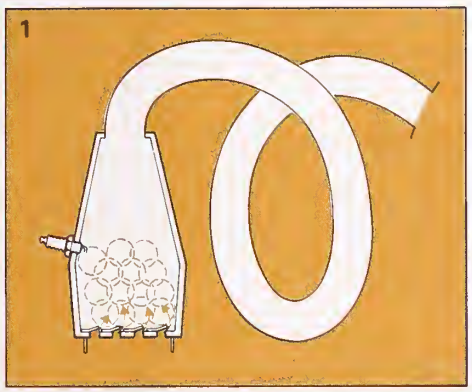
All of these furnaces have a drain to discharge the condensate that is a byproduct of combustion.

Pulse Combustion Furnaces/Boilers

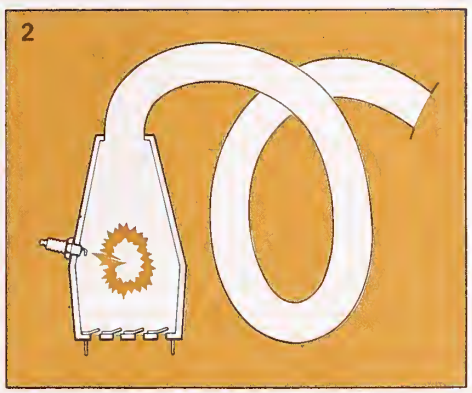
Pulse combustion is a revolutionary new technology in home heating. The process begins when small amounts of fuel and air are induced into a combustion chamber through valves (1 in the illustration). This mixture is ignited by a spark plug, causing the first pulse (2), which then causes the valves to close, forcing the products of combustion down the tail pipe (3). The length of the tail pipe is designed so that as the shock wave from the pulse reaches the end, it is reflected back to the combustion chamber.

Meanwhile, the pressure reduction in the chamber allows the valves to open again, admitting more gas and air (4). When the reflected wave re-enters the chamber, there is sufficient flame to ignite the new mixture, causing the

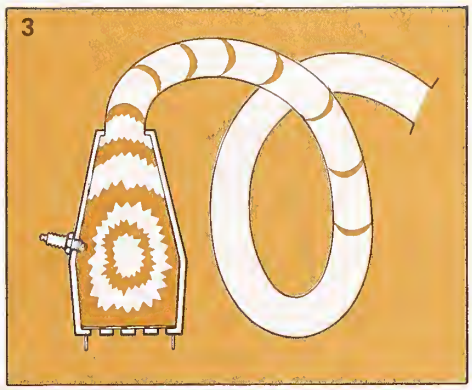
second pulse, starting the process all over again (5). Once combustion is started, it becomes self-perpetuating, and the combustion blower and spark igniter turn off. Combustion occurs 68 times a second.



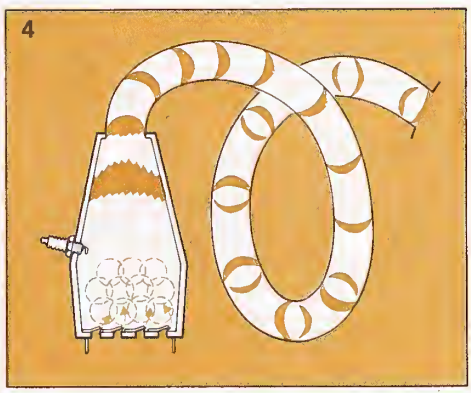
Gas/air mixture in combustion chamber.



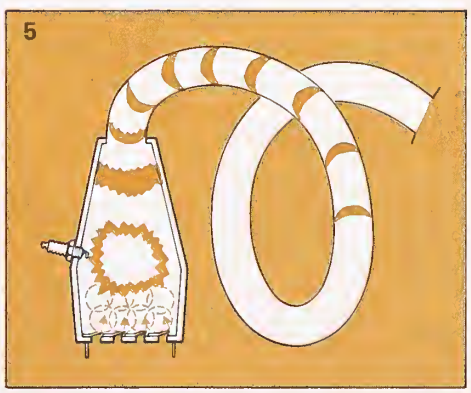
Mixture ignited by spark plug.



Combustion gases forced down tailpipe.



Combustion shockwave reflected back to combustion chamber.

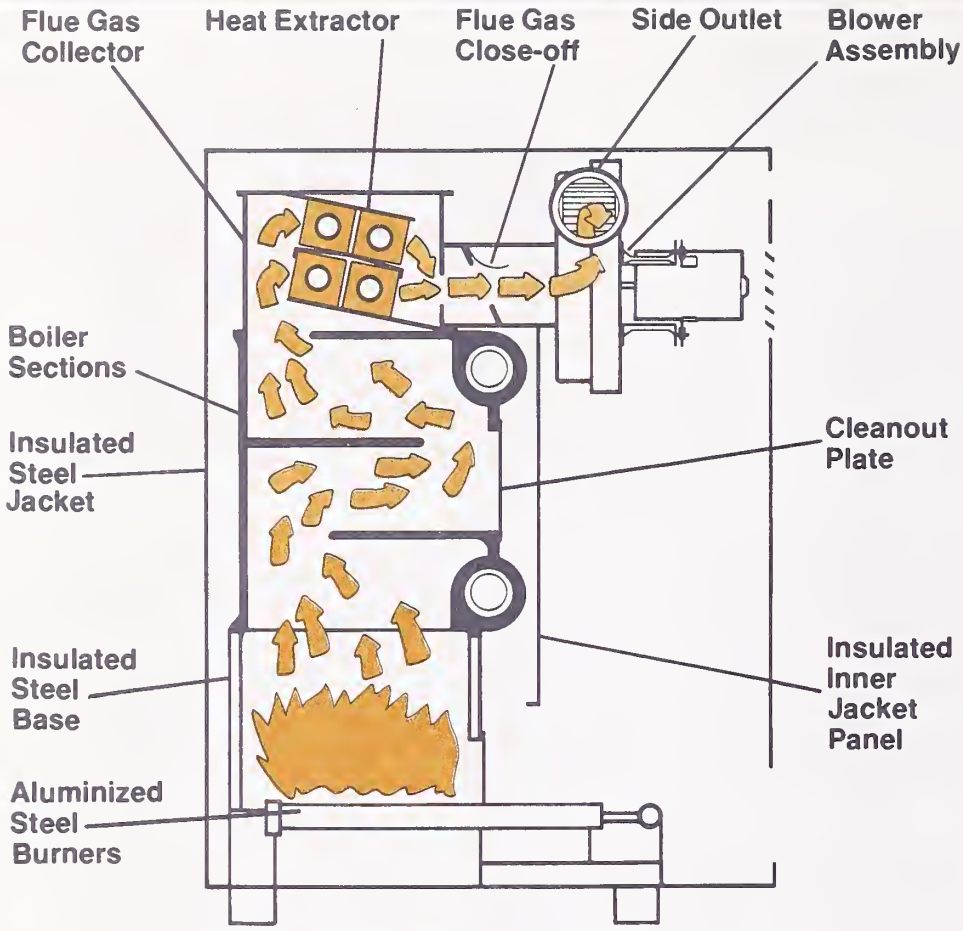


Reflected flame re-enters combustion chamber to ignite new mixture.

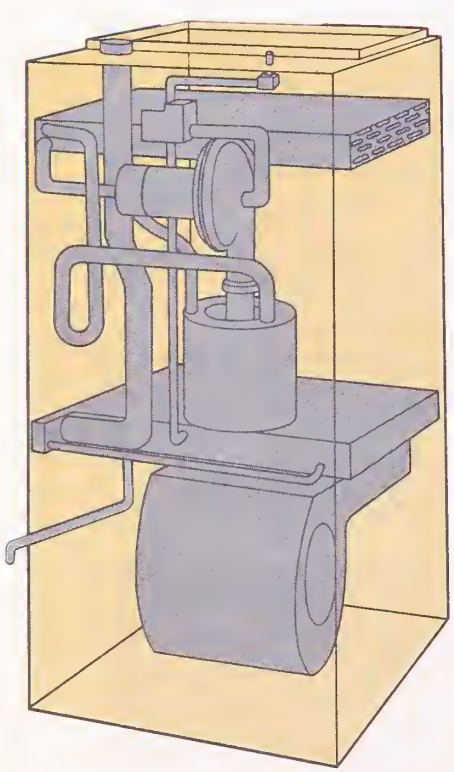
Induced Draft Furnaces and Boilers

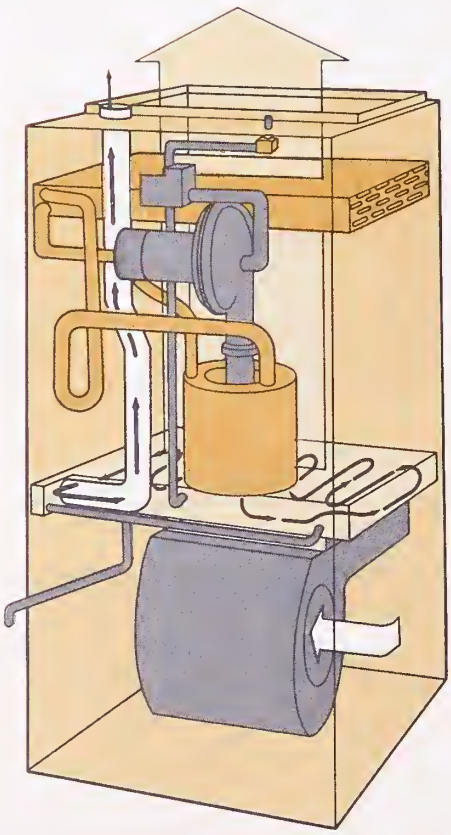
Induced draft design incorporates a fan that supplies combustion air for the furnace or boiler. Improved heat exchangers draw off the heat that would otherwise go up the chimney.

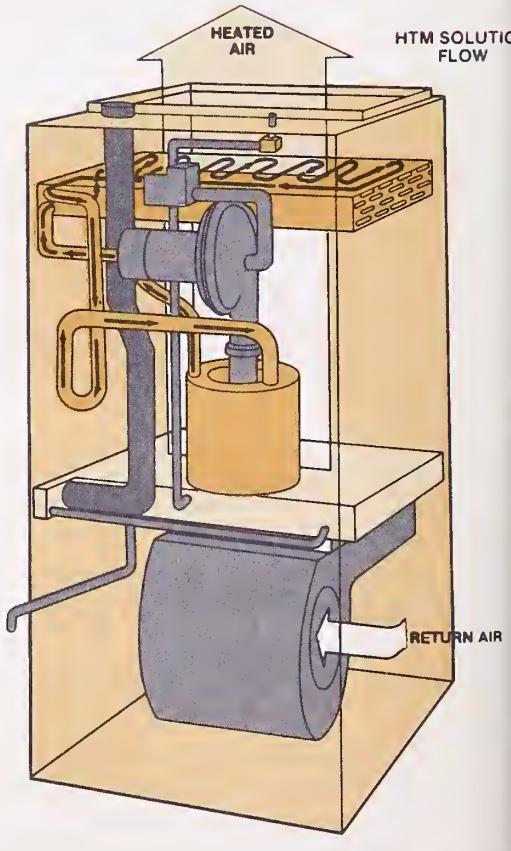
The fan increases the flue gas velocity through the heating unit, which increases heat transfer to the heat exchanger. Some designs eliminate the need for a chimney.



Induced Draft Boilers







Furnace Efficiency Ratings

The heating industry has several ways of describing a heating unit's efficiency. The most accurate method is the Annual Fuel Utilization Efficiency (AFUE) percentage. This system, developed by USDOE, is somewhat like an automobile's gas mileage ratings. The higher the AFUE percentage, the more efficient the heating unit.

If, for example, your system is rated at 93 percent AFUE, it means that 93 cents of your fuel dollar is being used to heat your home; the remaining 7 cents goes up the flue as waste heat.

The Federal Trade Commission requires manufacturers to make the AFUE rating of their heating products available to consumers. If you are considering a new heating system, ask your heating contractor or the manufacturer for a copy of the Energy Guide Fact Sheets that disclose the AFUE percentages (see page 81).

If you have a conventional 10- to 20-year-old heating system, it probably has an AFUE between 55 percent and 65 percent, which means that 35 to 45 cents of your fuel dollar is wasted. Newer conventional systems with add-ons like vent dampers have AFUE's between 75 percent and 82 percent.

New high efficiency systems have AFUE's as high as 97 percent.

The first step in selecting a new heating system is to have a professional heating contractor determine the Btu/h input capacity required for your home.

When you have learned the Btu/h input capacity your home needs, you can obtain Energy Guide Fact Sheets for each model available in that Btu/h capacity from various manufacturers.

Any given manufacturer may produce a range of different types of furnaces or boilers in the capacity you need—from simple conventional units with AFUE percentages in the 60s to highly efficient systems with AFUE percentages in the 90s.

If you have a big family and a large home, and plan to live in that house for some years, you might consider replacing your inefficient heating system with one of the 90 percent + AFUE range.

A Note About Installed Cost

Installation costs of any given system vary. Costs for installing the same equipment could vary significantly among contractors in the same area.

It is essential to obtain at least three bids from reputable contractors on any installation.

New high technology heating systems are more complicated than the outmoded 60 percent efficient gas or oil heating systems. They are so new that little is known about their maintenance requirements.

It is safe to assume that these systems are not totally maintenance free, given that they are more complex than their predecessors.

DNRC strongly suggests that persons interested in replacing their heating systems with high efficiency units select competent professional heating contractors with local references.

CHAPTER FIVE

WATER HEATERS

Many home owners don't realize how much energy it takes to heat water. Yet water heating normally is their second largest energy consumer, averaging 14 percent of a family's energy budget. Consider the

following comparisons. The average electric water heater consumes anywhere from 4800 to 5600 kWh of electricity per year. A 19-cubic-foot frost-free refrigerator/freezer consumes, on the average, 2260 kWh, and a 24,000 Btu air conditioner consumes 1410 kWh per year. These figures are averages only; actual usage depends on many things, including the number of people in the family, the size of the unit, usage patterns, and the amount of insulation on the unit. These averages show the relatively high energy use of the water heater.

There are two main ways to conserve energy in water heating: reduce the amount of hot water used, and modify the water heating system to prevent losses and increase the system's efficiency. Both can usually be accomplished at little or no cost and without any major change in living patterns.

NO-COST ENERGY SAVERS

1. Turn Down the Hot Water Thermostat. You may have your water heater thermostat set too high and not know it. This is especially likely if the heater is more than a few years old. Even those manufactured a few years ago were preset for 150°F; most are now preset at 140°F.

Because you probably mix hot water from your tap with cold water, you may not realize how hot the water really is. From a safety standpoint alone, the maximum temperature setting for the water heater should not exceed 125°F. When hotter than this, it can scald the skin.

Gas Research Institute studies demonstrate that reducing thermostat temperatures from 150°F to 140°F would result in an average daily energy consumption reduction of 7.7 percent; reducing it from 150°F to 130°F would reduce consumption by 10.6 percent, and reduction to 120°F would save 16.1 percent. From a conservation standpoint, 120°F is generally recommended. However, if you have a dishwasher without a heater to boost the temperature of the water to 140°F, you should keep the water heater set at 140°F. Check with the manufacturer of the dishwasher or the instruction manual if you are uncertain.

Lower temperatures will also prolong the life of your water heater. In many areas of Montana, the water contains dissolved minerals that can form lime scale. When heated to a certain point, these minerals settle on the bottom of your heater. The resultant lime scale causes reduced heat transfer, higher operating costs, and eventual failure of the system. The formation scale at 180°F is about seven times as great as that at 140°F, and lowering your tank temperature to 120°F will even further reduce the problem.

How do you determine whether you should lower your temperature setting? First, check the water temperature at the faucet farthest from the heater. Let the water run until it doesn't get any hotter. Then, fill a container and measure the temperature. Use a thermometer designed for higher temperatures, such as a candy thermometer. You will then have some idea of how much you can lower the setting on the heater and still have the water as hot as you need at the farthest faucet. For example, if the thermometer reads 130°F, try lowering the thermostat 10 degrees and then retest the temperature.

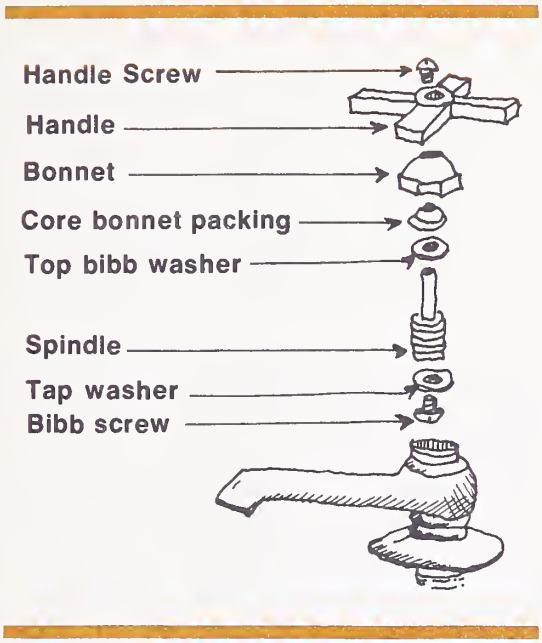
On most electric water heaters, the thermostat is marked in degree calibrations usually ranging from 110°F to 170°F. First turn off the electricity to the unit. Remove the panel covering the thermostat control and adjust the thermostat with a screwdriver.

Gas and oil models usually have a dial indicating "low," "medium," and "high" settings. If yours is unclear, check the owner's manual. In most cases,

warm or low is 110°–120°F
medium or normal is 140°F
hot or high is 160°F.

You can set the dial between these settings.

2. Fix Leaking Faucets. Leaks can waste as much as 3,000 gallons of water a year in your home, along with the energy needed to heat it. Often a leak can be fixed simply by replacing the tap washer. See the illustration of tap parts.

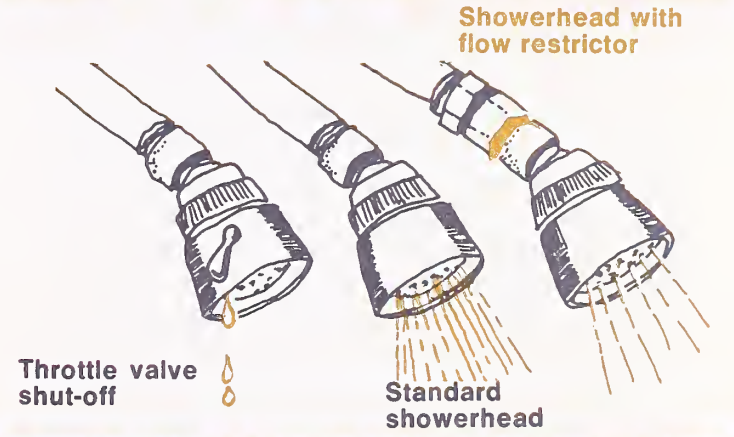


3. Drain Sediment from the Hot Water Tank. Every 3 months (more often if you have very hard water) drain water from the faucet near the bottom of your water tank until the water runs clear. This removes sediment and mineral deposits that form in the tank and can make the unit work harder and expend more energy to heat water. If you hear water gurgling when the heater is on, there is definitely sediment buildup.

Follow these procedures: First, turn the unit off by shutting off the oil, gas, or electricity. Then, close both the cold water inlet valve and the hot water outlet valve. Open a hot water faucet somewhere in the house so air can get into the tank. Drain the water through the heater faucet near the bottom until the water runs clear. To refill the unit, open the cold inlet valve and the hot outlet valve after closing the drain valve. When water starts flowing out of the open faucet in the house, the tank is full again and you may turn the unit back on. If you have a gas or oil model, check the instruction manual for directions on turning the unit on and off.

4. Try to Use Less Water.

— Do full loads of laundry and use the cold setting when possible.
— Use the dishwasher only when it is full.
— Turn off the water heater if you are going away for several days or more. If you have a gas hot water heater, be sure that the pilot light is turned off so that it doesn't accidentally go out and fill your house with explosive gas while you're on vacation.
— Install flow restrictors, aerators, or low-flow shower heads on showers and faucets. These use less water but do not decrease the water pressure. If the flow rate of your shower exceeds 3 gallons per minute, the head should be replaced or a restrictor installed. These devices can reduce hot water usage for bathing (normally 40 percent of total household use) by half.



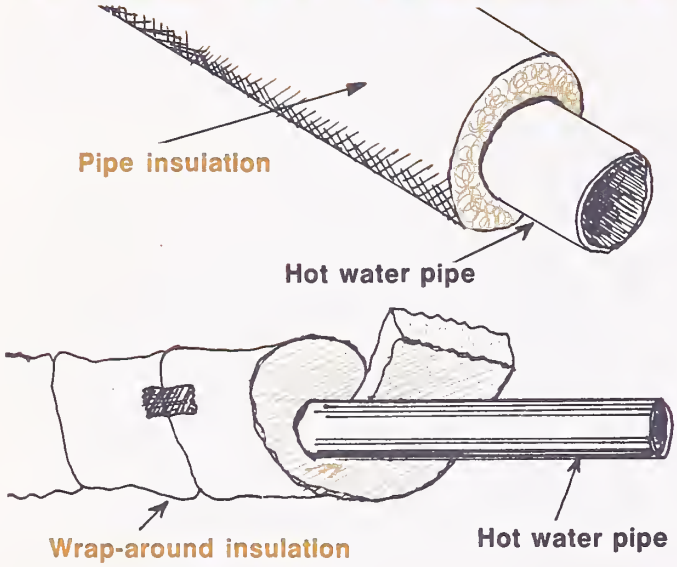
5. Inspect and Maintain Your Water Heating System. You should have your hot water system inspected and maintained along with your space heating system.

OTHER HOT WATER CONSERVATION MEASURES

1. Insulate Hot Water Pipes. Insulate exposed hot water pipes in uninsulated areas with ½-inch foam, pipe tape, or pipe insulation wrap to cut heat loss that occurs when hot water flows from the tank to the faucet. Insulate at least the first 4 feet of exposed pipe taking hot water from the tank. This is a good investment even if your tank is in a heated area.

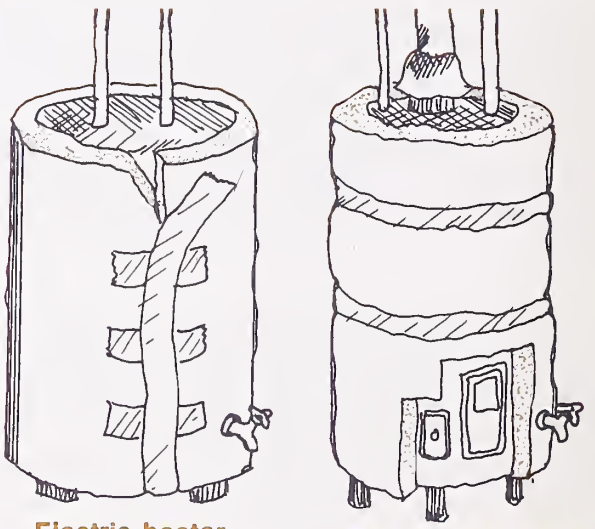
Pipe insulation wrap is relatively simple to install. There is a slit running along the length of the insulation, and it slips easily onto the

pipe. Once it is in place, apply duct tape along the slit to secure the wrap. Fiberglass insulation can also be cut and wrapped around the pipes and secured with tape. Insulation in exposed or unheated areas helps prevent pipes from freezing.



2. Insulate Your Water Tank. Although most water tanks are factory insulated, adding more insulation is an inexpensive way to achieve savings. Even if your water heater is well insulated (and many new water heaters have an R-16 to R-20 rating), it's still cost-effective to install an additional wrap of R-11 insulation. If the tank feels warm to the touch, consider insulating it. Insulation kits designed to fit most water heaters are now available. They are energy-saving, economical (about $20), and safe when properly installed. Or you can make your own cover for an electric water heater by using a 3-inch fiberglass batt and duct tape. Caution: Be extremely careful when installing the kit on gas or oil units. Follow the kit instructions precisely. Do not block the air flow to the pilot light. Do not cover the top or bottom of the unit. Do not cover the controls. Wrap the exterior and the top, but do not cover the control panels or the bottom of the unit.

Recent studies by the Bonneville Power Administration show that installing at least 3 inches of rigid insulation *under* an electric water tank will save significant energy, because the pad will prevent energy from escaping into your floor. Don't do this with gas heaters, though—you might block the combustion air supply. DNRC has a booklet called "Hot Water—Insulate and Save!" that shows you step-by-step how to insulate an electric or gas water heater.

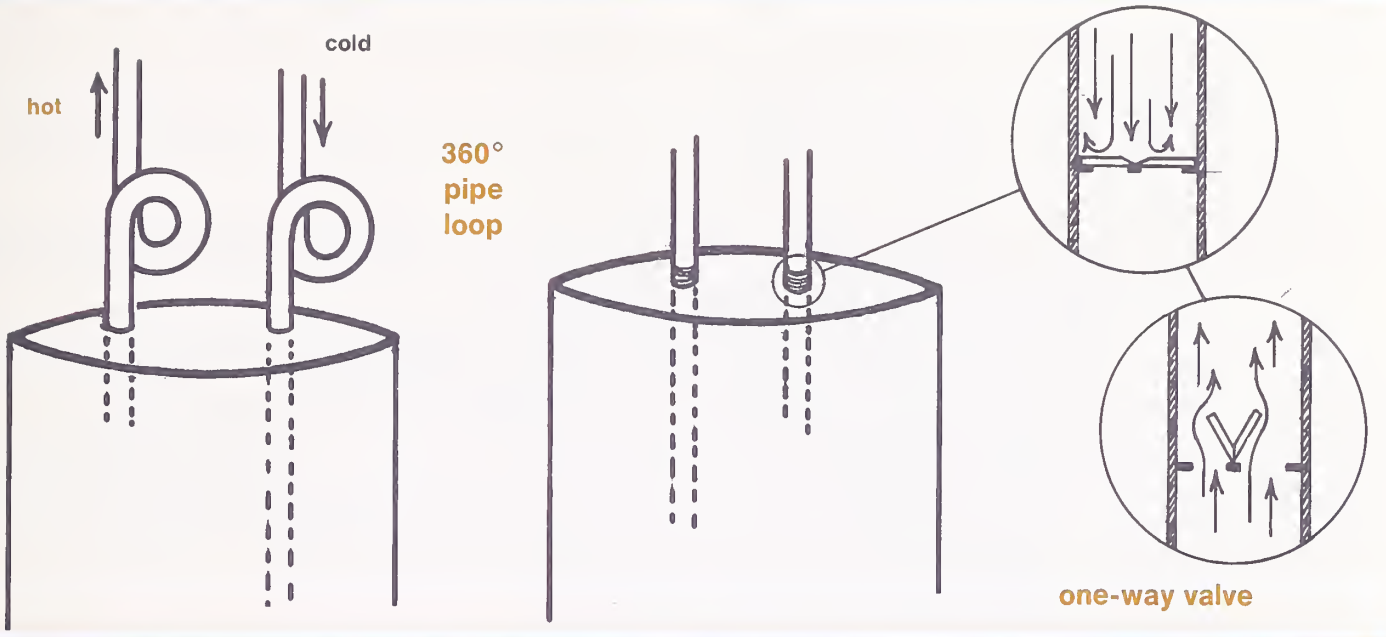


Thermal Traps

Water pipes are another escape route for heat. A simple device called a thermal trap can be installed on either a new heater or an older one.

A thermal trap can be either a 360° loop or a one-way valve. The loop keeps heat from escaping by allowing hot water to rise only as far as the top of the loop, which is near the tank. Without such a device, a considerable length of pipe contains hot water which loses its heat to the surrounding air. As the water cools, it sinks and must be reheated. The one-way valve can be easily installed where the pipes are attached to the tank. It prevents cool water in the pipes from settling into the tank and being replaced by hot water.

Using one of these devices and insulating both your tank and the first few feet of pipe will ensure the least possible heat loss from your water heating system.



BUYING A NEW WATER HEATER

An informed purchasing decision (as discussed below) can save a significant amount of money in operating cost over the estimated 7-to 10-year life of a water heater. Using the heater in an energy-conscious way will save you even more money.

Install the water heater as close as possible to the area where the largest volume of hot water will be used. Since heat is constantly lost through hot water pipes, the shorter the pipe, the lower the heat loss.

Have the heater installed by an experienced plumber familiar with local regulations.

1. Determining Your Needs. It is a common practice to replace a water heater with one of the same tank capacity. This could be a costly error if the old tank was larger than necessary for your needs.

Clearly, the morning and evening demand for hot water is very different in the household of a retired couple than for a family with three or four children.

Your needs are based on what is termed peak hour demand, not on tank/storage capacity. Peak hour demand is the busiest 1-hour period of the day for the water heater. This is usually in the morning in most households.

Use	Average Gallons of Hot Water per Usage		Times Used During One Hour		Gallons Used in One Hour
Shower	20*	X		=	
Bath	20	X		=	
Shaving	2	X		=	
Hands and Face Washing	4	X		=	
Hair Shampoo	4	X		=	
Hand Dishwashing	4	X		=	
Automatic Dishwasher	14	X		=	
Food Preparation	5	X		=	
Wringer Clothes Washer	26	X		=	
Automatic Clothes Washer	32**	X		=	
TOTAL *(Peak Hour Demand)*					(First Hour Rating)

*reduce to 12 gallons if using water-saving shower head.
**reduce to 0 gallons if using cold water washing procedure.

To find the right size water heater for your household's bathing, laundry, and dishwashing needs, estimate your peak hour demand/first-hour rating from the following table developed by the Gas Appliance Manufacturers Association. Use this rating, not tank capacity, in buying a new water heater.

Use	Avg. Gals. Hot Water Per Use		Maximum Times Used During One Hour		Maximum Gals. Used In One Hour
Shower	20*	×		=	
Bath	20	×		=	
Shaving	2	×		=	
Hands & Face Washing	4	×		=	
Hair Shampoo	4	×		=	
Hand Dishwashing	4	×		=	
Automatic Dishwashing	14	×		=	
Food Preparation	5	×		=	
Wringer Clothes Washer	26	×		=	
Auto. Washer	32**	×		=	
Total (Peak Hour Demand)					

*Reduce to 12 gallons if using water-saving shower head.
**Reduce to 0 gallons if using cold water washing procedure.

2. Estimating Fuel Costs. The next step in your purchase decision should be to compare the energy efficiencies of different fuel types, unless you are restricted as to fuel type—such as in an all-electric home, for example.

These basic operating cost data can be found on the yellow and black Energy Guide label that the federal law requires to be posted on every water heater for sale. (Refer to the Energy Guide Appliance Label—Chapter Six.)

You should purchase only from among models with the lowest dollar energy cost as shown on the left of the bar scale.

Here's what to look for in energy efficient water heaters:

1. Over 1½ inches of tank insulation (2 inches or more in electric water heaters). Standard units have 1 inch of insulation.

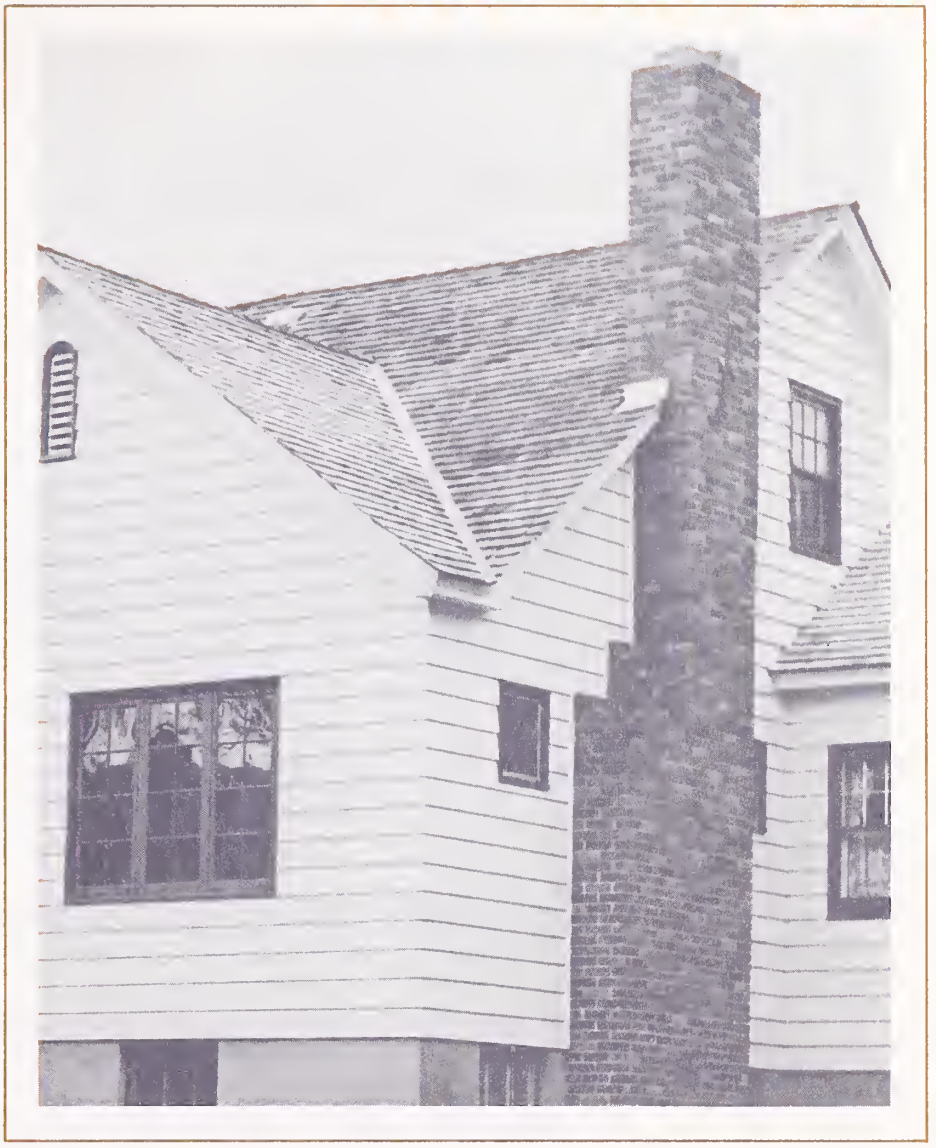
2. Pilot lights that use less gas than standard models, and less natural gas in the heating flame.

3. Several top-of-the-line electric water heaters come with built-in automatic clock thermostats that control water heating very much as your house thermostat controls house heating. This feature can reduce the temperature of the water overnight when there is no demand, and automatically restore the water temperature to the desired level early in the morning.

Retrofitting such an optional automatic thermostat also can be an excellent investment in long-term energy cost savings for your present electric water heater. It should be installed by a licensed electrician. Unfortunately, automatic thermostats are not available for natural gas or oil-fired water heaters.

CHAPTER SIX

PAYBACK AND ENERGY GUIDE LABELING



Payback period is the time necessary to realize a savings equal to the cost of a more efficient energy system. USDOE and DNRC suggest that payback for home energy improvements should be no more than 7 years.

When you buy a new, highly efficient energy system, your savings start

immediately in the form of lower heating and cooling bills, and continue through "payback" until a replacement system must be purchased.

ENERGY GUIDE LABELING

Type of appliance and capacity.

Estimated annual operating cost for this model only.

Name of manufacturer and model number of the appliance on which this label appears.

All model numbers are listed if the label applies to more than one model.

National average cost for electricity upon which the estimated annual energy cost figure is based.

All brands and models compared in the scale on this label fall within this capacity range.

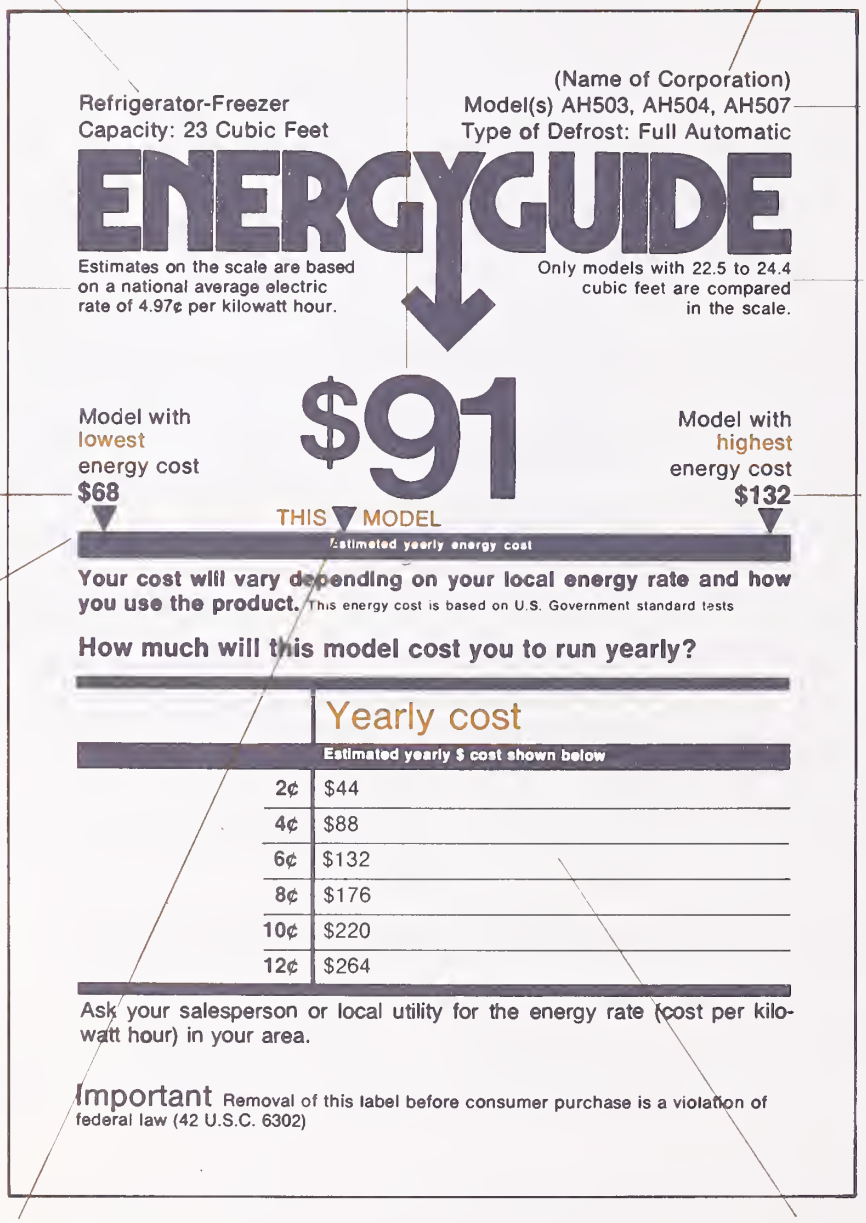
Estimated annual operating cost for the model in this size range that costs *least* to operate.

Estimated annual operating cost for the model in this size range that costs *most* to operate.

Scale showing lowest and highest estimated operating costs for models within this size range. These models represent different brands, not just those of the company listed in the upper right-hand corner.

Where the estimated annual cost of this particular model falls in comparison to all other models in this size range.

A grid to help determine more closely the customer's operating cost based on local utility rates and use habits.



(Name of Corporation)
Model(s) AH503, AH504, AH507
Refrigerator-Freezer
Capacity: 23 Cubic Feet
Type of Defrost: Full Automatic

ENERGYGUIDE

Estimates on the scale are based on a national average electric rate of 4.97¢ per kilowatt hour.

Only models with 22.5 to 24.4 cubic feet are compared in the scale.

Model with lowest energy cost **$68**

$91

THIS MODEL

Model with highest energy cost **$132**

Estimated yearly energy cost

Your cost will vary depending on your local energy rate and how you use the product. This energy cost is based on U.S. Government standard tests

How much will this model cost you to run yearly?

	Yearly cost
	Estimated yearly $ cost shown below
2¢	$44
4¢	$88
6¢	$132
8¢	$176
10¢	$220
12¢	$264

Ask your salesperson or local utility for the energy rate (cost per kilowatt hour) in your area.

Important Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302)

The EnergyGuide Label

To help consumers reduce their energy costs, USDOE and the Federal Trade Commission created the Appliance Labeling Program for seven types of appliances that are heavy energy users. These appliances must prominently display a 5 x 7-inch black and yellow "Energy Guide" label.

The purpose of the Energy Guide label is to allow you to compare similar models so that you can determine which appliance will cost less to operate on an annual basis. You should expect to pay more initially for some of these energy efficient appliances because of the energy-reducing features incorporated into their design and construction.

A GRAIN OF SALT

Don't be duped by names. Marketers can name their appliances almost anything they wish. Names like "Energy Miser," "Energy Saver," "Fuel Saver," and the like don't necessarily mean anything. The best way to determine energy efficiency of appliances is to compare the Energy Guide labels or consult the directories we recommend in this book.

HOW TO READ THE ENERGY BAR SCALE

The Energy Guide label tells you how the model you're considering performs relative to the two extremes: the model that uses the most energy and the model that uses the least energy. A "best buy" should always be on the low side in energy consumption, though the specific needs of the user determine which model would best match the intended purpose.

You should always consider how you use certain appliances when you are trying to determine which model is best for you. A young family with two school-age children opens a refrigerator door more often than a single home owner. The same energy-efficient appliance may be under-used by the single home owner who could easily scale down capacity requirements and omit such extras as a crushed ice and cold water dispenser in the door.

Also, DNRC advises that any so-called "energy efficient" appliance or system isn't a best buy if it takes more than 7 years to pay for itself in savings.

Energy Guide Arithmetic

If you're shopping for the best buy in, say, a new 23-cubic-foot refrigerator/freezer, you can use the black and yellow Energy Guide label to arrive at an informed decision, as follows.

The label compares three 23-cubic-foot refrigerator/freezers with comparable automatic defrost features. Model A has the highest energy cost; $132 annually to operate. Model B—the most energy-efficient unit—costs only $68 a year to run. The model you're considering in the store costs $91 a year to run (Model C).

Let's say that the purchase price of Model A is $600, Model C is $700, and Model B is $900.

First find the purchase price differences among the models. You might conclude that B, the most energy efficient model, has a purchase price beyond your budget. You then compare A and C, which you can afford. You determine that C has a purchase price of $100 above A

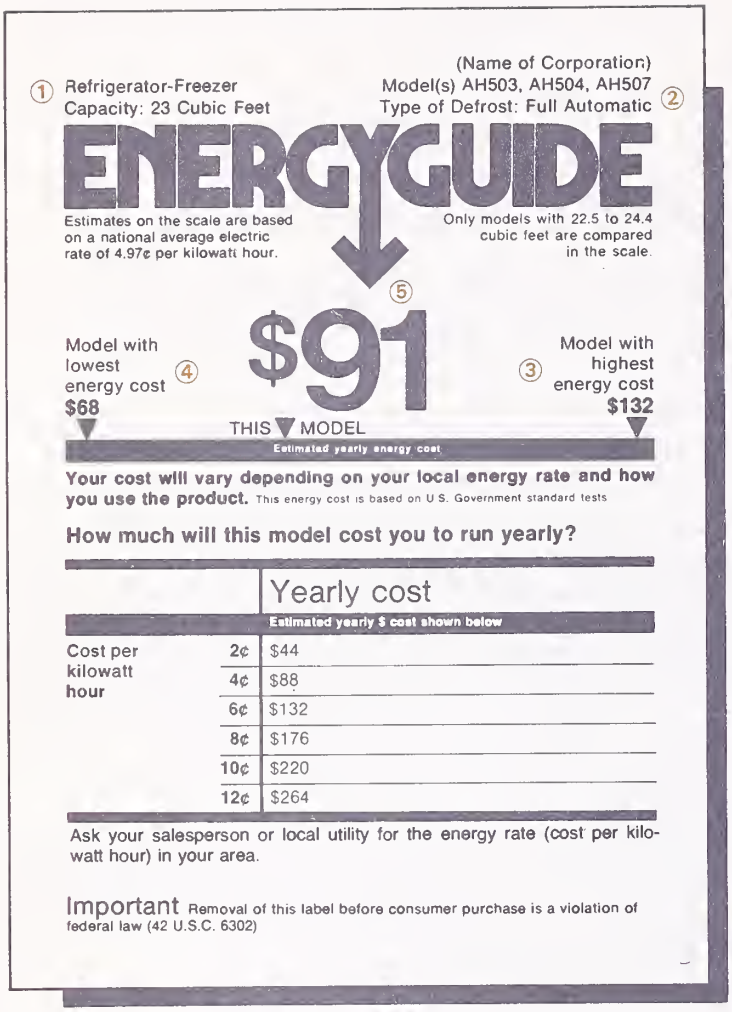
Next find the difference between the annual operating cost of the two by subtracting the lower yearly operating cost from the higher yearly operating cost:

$132 for Model A - $91 for Model C = $41

Finally, divide the difference in initial purchase price ($100 between A and C) by the difference in yearly operating cost.

$100 ÷ $41 = 2.4 years

It will take almost 2½ years for the lower operating cost of Model C to offset its higher initial purchase price, with a $41 savings each year, for a $615 total savings over the expected 15-year lifetime of this refrigerator-freezer. Since you paid $100 more for this energy efficient model, your net lifetime savings would be $515.


(Name of Corporation)
① Refrigerator-Freezer
Capacity: 23 Cubic Feet
Model(s) AH503, AH504, AH507
Type of Defrost: Full Automatic ②
ENERGYGUIDE
Estimates on the scale are based on a national average electric rate of 4.97¢ per kilowatt hour.
Only models with 22.5 to 24.4 cubic feet are compared in the scale.
⑤
Model with lowest energy cost ④ $68
$91
Model with highest energy cost ③ $132
THIS MODEL
Estimated yearly energy cost
Your cost will vary depending on your local energy rate and how you use the product. This energy cost is based on U.S. Government standard tests.
How much will this model cost you to run yearly?
Yearly cost
Estimated yearly $ cost shown below
Cost per kilowatt hour
2¢ $44
4¢ $88
6¢ $132
8¢ $176
10¢ $220
12¢ $264
Ask your salesperson or local utility for the energy rate (cost per kilowatt hour) in your area.
Important Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302)

If the cost of electricity rises, your annual savings become even greater and with a quicker payback.

Be sure to compare only models with the same features—not models with features you don't want.

FOUR DIFFERENT TYPES OF ENERGY GUIDE LABELS

There are four types of Energy Guide labels. One type is specifically for furnaces. The second type is for room air conditioners. The third type applies to dishwashers, water heaters, and clothes washers, and the fourth type appears on refrigerators, freezers, and clothes dryers.

Electric and gas ranges are not covered by the Appliance Labeling Program. This is because brands and models of a given size or fuel type vary little in energy use. This also is true of television sets, humidifiers, and dehumidifiers, where there is little difference in energy consumption among different makes and models and they do not represent a significant portion of your energy cost.

FURNACES

The label on furnaces is a "generic" label—more like a notice—directing the buyer to an energy fact sheet developed by the manufacturers, which dealers and heating system contractors should have on file for each product they sell or install. This fact sheet provides information on the estimated annual efficiency of furnace models in specific categories of Btu/hour heating capacity.

The efficiency ratings are developed under USDOE test procedures for furnaces and boilers by an independent testing laboratory and administered by the Gas Appliance Manufacturers Association (GAMA), a voluntary industry trade group.

Each furnace or boiler must display the GAMA Certification Seal—an indication that the Annual Fuel Utilization Efficiency (AFUE) rating and output heating capacity of the furnace or boiler have been determined and are accurately stated in accordance with the applicable USDOE efficiency test methods.

The many installation variables that affect the operating efficiency of furnaces and boilers—such as size and design of the structure in which it is to be used and layout of the pipes or duct work—make it impossible to present accurate operating cost data on a Guide label. It's presented, instead, on the fact sheet that contains information on each system component, overall system efficiency for different combinations of components and energy cost. Most important of all, the fact sheet contains an efficiency comparison to other brands of the same Btu/hour range.

Once a professional heating contractor or supplier shows you his calculation of the capacity (Btu/hour output) required for your home, all you need do is refer to the fact sheets to compare the efficiency of various brands in the appropriate Btu/hour range.

FACT SHEET EXAMPLE

If gas costs about 80 cents per therm (100,000 Btus or 100 cf) and your home has a heat loss of 60,000 Btu per hour (as determined by a heating professional), here's how to calculate your cost and savings options from this Energy Guide fact sheet:

70.6 percent AFUE Model

Double the 40 cents per therm cost of $551 estimated annual operating cost found in the '60' column. This works out to an annual cost of $1,102 at 80 cents per therm.

80.5 percent AFUE Model

Follow same procedure as above. This works out to an annual cost of $968 at 80 cents per therm for this more efficient model.

1. The difference in annual operating cost is

$1,102 - $968 = $134.

2. Find the difference in purchase price between the two models.

Let's say the 70.6 percent AFUE model costs $1,100 and the 80.5 percent AFUE model costs $1,650. Therefore:

$1,650 - $1,100 = $550

3. Divide the difference in initial purchase price ($550 in this example) by the difference in yearly operating cost ($134).

Thus:

$550 ÷ $134 = 4.1 years

It will take about 4 years for the lower operating cost of the more expensive energy efficient model to offset its higher initial purchase price. At a $134 a year saving each year, you should expect to save $2,680 over the expected 20-year lifetime of this natural gas furnace.

Since you paid $550 more for this energy efficient model, your net lifetime savings would be:

$2,680 - $550 = $2,130

Remember, this was a comparison of one manufacturer's gas furnace options in the required Btu range. It is essential to examine other manufacturers' Energy Guide fact sheets (or directories) to determine if they have models more efficient than the 80.5 percent AFUE model, and if their installed costs and payback are more favorable.

MaxiTherm Type JV Natural Gas

RANGE OF COMPARABILITY: Only models with **77,000 to 93,000 BTU/hr.** capacities are used in the tables below.

Model JVT-500

Natural Gas
Standing Pilot

Capacity:
81,000 BTU's per hour

Least Efficient Model ▼ 55.00 — 68.3% This Model ▼ — Most Efficient Model ▼ 85.90

ESTIMATED ANNUAL EFFICIENCY

Cost per Therm	BTU heat loss of home (1,000 BTU per hour) 40	45	50	60
10¢	$102	$114	$126	$150
20¢	197	220	244	291
30¢	291	326	361	431
40¢	386	432	479	571
50¢	481	539	596	711
60¢	576	645	714	851

Annual Energy Cost (dollars)

Model JVS-500

Natural Gas
Electric Pilot Ignition

Capacity:
82,000 BTU's per hour

Least Efficient Model ▼ 55.00 — 70.6% This Model ▼ — Most Efficient Model ▼ 85.90

ESTIMATED ANNUAL EFFICIENCY

Cost per Therm	BTU heat loss of home (1,000 BTU per hour) 40	45	50	60
10¢	$97	$109	$121	$146
20¢	187	211	234	281
30¢	278	312	347	416
40¢	368	414	459	551
50¢	458	515	572	686
60¢	548	616	685	822

Annual Energy Cost (dollars)

Model JVS-500

Natural Gas
Electric Pilot Ignition with Automatic Vent Damper

Capacity:
82,000 BTU's per hour

Least Efficient Model ▼ 55.00 — 80.5% This Model ▼ — Most Efficient Model ▼ 85.90

ESTIMATED ANNUAL EFFICIENCY

Cost per Therm	BTU heat loss of home (1,000 BTU per hour) 40	45	50	60
10¢	$85	$96	$107	$128
20¢	165	185	206	247
30¢	244	274	305	365
40¢	323	363	403	484
50¢	402	452	502	603
60¢	481	541	601	722

Annual Energy Cost (dollars)

Energy cost estimates are based on the national average of 2,080 heating load hours. The energy costs and efficiency rating for the model with Electric Pilot Ignition and Automatic Vent Damper apply only when the vent damper is supplied by MaxiTherm. Use of any other damper will generally result in higher energy costs and lower efficiency ratings.

A page from a typical Energy Guide Fact Sheet comparing three of one manufacturer's gas furnaces in the 77,000 to 93,000 BTU/h range. Note how the addition of pilotless ignition and a vent damper raises the AFUE (annual fuel utilization efficiency) from 70.6% to 80.5% with the same BTU output. That's a 10% saving on operating cost.

All of these computations are based on current fuel costs and the comparisons assume that each of the fuel costs will rise or fall in a proportionate manner.

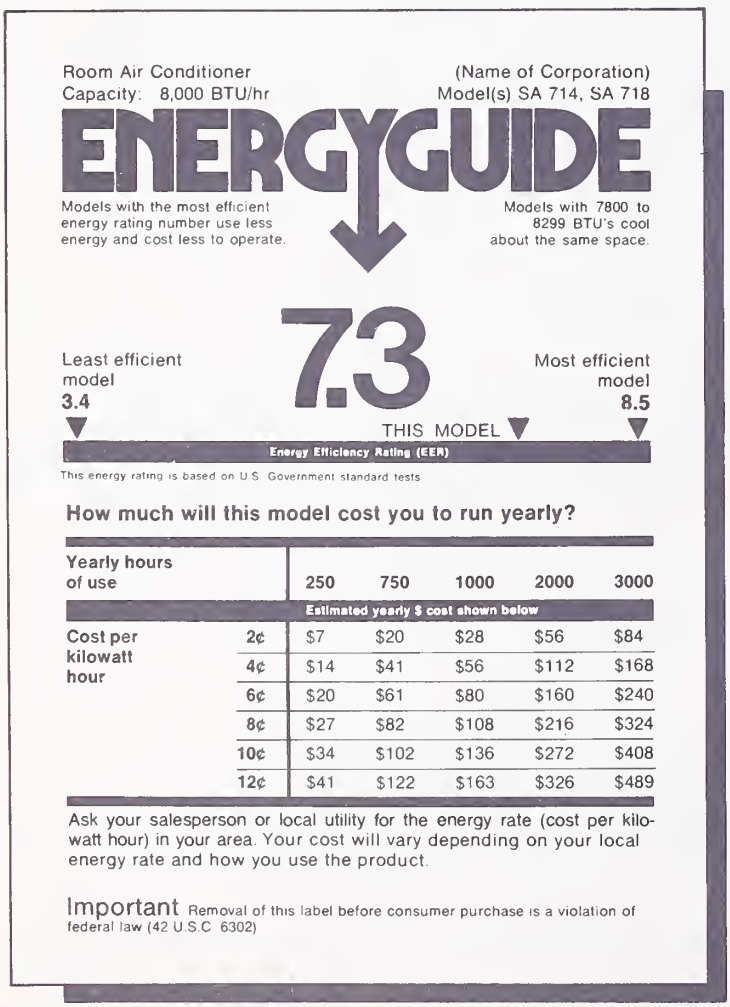
Similar generic labels and fact sheets for central air conditioning systems are also required by law, and contractors and suppliers should have these references on hand for your inspection at any time.

Purchasing a new furnace or boiler is costly. It may be prudent to obtain the Directory of Certified Furnace and Boiler Efficiency Ratings published twice annually by GAMA, which is available for $5.00 from:

GAMA Efficiency Certification Program
ETL Testing Laboratories, Inc.
Industrial Park
Cortland, NY 13045
(607) 753-6711

ROOM AIR CONDITIONERS

The Energy Guide label for room air conditioners presents numbers that relate to Energy Efficiency Ratio (EER); the large number on the Energy Guide label is not a dollar amount but indicates the efficiency of the appliance. A higher number indicates a more efficient appliance.



Room Air Conditioner
Capacity: 8,000 BTU/hr

(Name of Corporation)
Model(s) SA 714, SA 718

ENERGYGUIDE

Models with the most efficient energy rating number use less energy and cost less to operate.

Models with 7800 to 8299 BTU's cool about the same space.

Least efficient model **3.4**

7.3

THIS MODEL

Most efficient model **8.5**

Energy Efficiency Rating (EER)

This energy rating is based on U.S. Government standard tests

How much will this model cost you to run yearly?

Yearly hours of use		250	750	1000	2000	3000
		Estimated yearly $ cost shown below				
Cost per kilowatt hour	2¢	$7	$20	$28	$56	$84
	4¢	$14	$41	$56	$112	$168
	6¢	$20	$61	$80	$160	$240
	8¢	$27	$82	$108	$216	$324
	10¢	$34	$102	$136	$272	$408
	12¢	$41	$122	$163	$326	$489

Ask your salesperson or local utility for the energy rate (cost per kilowatt hour) in your area. Your cost will vary depending on your local energy rate and how you use the product.

Important Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302)

The EER is the ratio of the cooling capacity of the unit (expressed in Btu/hour) to the amount of electric power (expressed in watts) drawn by the unit. The higher the Btu/hour rating, the greater the cooling capacity.

The horizontal bar on the label shows a range of EERs for other room air conditioners of about the same cooling capacity. This is how you can make shopping comparisons.

Besides EERs, the label provides an operating cost chart enabling you to calculate the cost of using the air conditioner based on local electricity rates and hours of use. Your current electric utility bill will give you the price you pay for electricity per kWh.

Don't buy more cooling capacity than you need. A room air conditioner with too much cooling capacity will not run long enough to lower the humidity, resulting in a cold, clammy feeling in the room. A unit that's too small will not be able to cool the room adequately.

Estimating cooling load is not guesswork. A competent salesperson can compute the required cooling capacity on the basis of the following factors:

- Number of rooms to be cooled
- Wall, ceiling, and floor area materials and insulation
- Number and size of windows
- Amount of shade around the home
- Number of occupants
- Heat-producing appliances in the home
- Geographical location.

For best results, buy a unit within ±5 percent of the load estimate.

The Association of Home Appliance Manufacturers (AHAM) publishes three brochures of interest to purchasers of room air conditioners:

"Cooling Load Estimate Form: Facts You Should Know About Room Air Conditioners" costs 35 cents and shows you how to calculate the proper Btu/hour cooling capacity, discusses EERs, installation requirements, and efficient use and maintenance tips.

"Cooling Load Guide, Square Foot Method: Facts You Should Know About Room Air Conditioners" costs 35 cents and includes a simplified calculation form for determining the cooling capacity needed using the square foot method; however, the results obtained are not as accurate as those results obtained by using the Cooling Load Estimate Form.

"AHAM's Directory of Certified Room Air Conditioners" costs $1.00 and is essential for your chair side comparison shopping among 22 brands and 700 models of room air conditioners along with Btu/hour cooling capacity and other information.

To obtain the brochures, write to:

AHAM
20 N. Wacker Dr.
Chicago, IL 60606
(312) 984-5800

(Orders less than $5.00 must be accompanied by a check or money order.)

The Air Conditioning and Refrigeration Institute (ARI) sponsors and administers testing and rating programs for central air conditioning systems, central system humidifiers and room air conditioners, among other products. Twice each year ARI publishes a directory listing the results of testing and certification of more than 90 percent of the systems made in the United States.

The directory costs $3.00 and is available from:

ARI
1815 N. Fort Meyer Dr.
Arlington, VA 22209

The ARI Certification symbol appears on the refrigeration compressor component of all certified cooling systems and is your assurance that the product has been independently tested to meet USDOE standards and that the test results are accurately stated.

If you are considering the purchase of central air conditioning or room air conditioners, it might be prudent to make your preliminary efficiency comparisons from this directory.

The SEER Rating

The Seasonal Energy Efficiency Ratio (SEER) is used instead of an EER on central air conditioning systems. The SEER indicates the relative amount of energy needed to provide a specific cooling output. It simply expresses the total cooling Btus required during the air conditioner's normal usage period, divided by the total electric energy input in watt/hours for the same period.

The SEER rating can be a money-saving guide for you when purchasing a new air conditioning system. For example, assume that a cooling contractor examines your home and calculates that you'll need a cooling capacity of 36,000 Btu/h. Assume that the cooling season for your part of Montana averages about 400 hours, and assume that the average summer electric rate is about 4.0 cents per kWh (refer to your utility bill for the actual current rates).

Now, say that you're looking at two different central air conditioning systems, one with a SEER of 6.0 and one with a SEER of 8.0. To compare the operating costs of these two units, apply the following formula:

$$\frac{\text{Capacity (Btu/h)}}{\text{SEER}} \times \frac{\text{Cooling Load (Hours)}}{1{,}000} = \text{Cost of Operation}$$

So, for our examples of air conditioners with SEER ratings of 6.0 and 8.0:

$$\text{SEER 6.0:} \quad \frac{36{,}000}{6.0} \times \frac{400}{1{,}000} \times \$.04 = \$96.00$$

$$\text{SEER 8.0:} \quad \frac{36{,}000}{8.0} \times \frac{400}{1{,}000} \times \$.04 = \$72.00$$

From this example it's clear that the higher efficiency unit would save $24.00 (the difference between $96.00 and $72.00) each cooling season. Since the more efficient unit is often more expensive to purchase, you then need to calculate the difference in purchase price and divide by your annual savings. This will give you the simple payback period in which the more efficient unit will pay for itself through lower utility bills.

WHEN TO BUY

Think ahead. Summer isn't the best time to call air conditioning contractors. Chances are they won't be able to get around to you for several weeks.

You'll receive more favorable time and attention in the late winter or early spring; and, depending on their work load, they may be more willing to bargain on the total system cost. The Air Conditioning and Refrigeration Institute also cautions to beware of the contractor who offers unrealistically low prices. "It may mean corners are being cut in crucial areas," ARI warns.

Replacing an Old Air Conditioning System

The useful life of a central air conditioning system can vary greatly. On the average, a residential central air conditioning system will last from 10 to 15 years, according to ARI. Major components—motors or the compressor—are usually the first to wear out. The decision you're faced with is whether to repair the existing equipment or replace it with new equipment.

In the short run, replacing failed components will cost the least, but it could make more economic sense to put the cost of repair into a new, energy efficient model that will immediately reduce operating costs and pay for itself within 7 years.

If you've carefully weatherstripped and insulated your home and perhaps installed storm windows since installing the old system, it's likely your new replacement air conditioner will need less cooling capacity. That could represent important savings on the purchase price and operating costs. This is why it is very important for a cooling specialist to accurately calculate your home's current cooling load requirements. Installing a new system with the same capacity as the old is not wise.

HOT WATER APPLIANCES

One type of Energy Guide label appears on appliances that use or produce hot water, specifically dishwashers, water heaters, and clothes washers. This label shows two dollar amounts, one based on costs for that appliance when its hot water is supplied from an electric heater and the other pertaining to the cost from a gas water heater.

WATER HEATERS

The water heater Energy Guide label lists energy efficiency factors in terms of dollar amount like the refrigerator/freezer label. On this label, the capacity of the water heater is stated in terms of "first-hour rating," or the amount of hot water that can be produced in

an hour of operation. Consumers must compare equivalent first-hour ratings, not the tank's liquid capacity.

Water Heater-Oil

(Name of Corporation)
Model(s) RP23, RP38

ENERGYGUIDE

Estimates on the scale are based on a national average oil rate of 62¢ per gallon.

Only models with first hour ratings of 75 to 86 gallons are used in the scale

Model with lowest energy cost **$127**

$134 THIS MODEL

Model with highest energy cost **$159**

Estimated yearly energy cost

Your cost will vary depending on your local energy rate and how you use the product. This energy cost is based on U.S. Government standard tests

How much will this model cost you to run yearly?

		Yearly cost
		Estimated yearly $ cost shown below
Cost per gallon	52¢	$137
	56¢	$145
	60¢	$153
	64¢	$161
	68¢	$169
	72¢	$177

Ask your salesperson or local utility for the energy rate (cost per gallon) in your area.

Important Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302)

Energy costs for gas, electric, and oil-fired water heaters are calculated periodically by the Federal Trade Commission and manufacturers update the labels accordingly.

CLOTHES WASHERS

Two capacity classifications are used for labeling clothes washers:

COMPACT = less than 1.6 cubic feet tub capacity

STANDARD = 1.6 cubic feet or more tub capacity

About 90 percent of the energy used for automatic clothes washing is for heating water, so it's wise to choose a model with controls to select various water volumes to match the size of the wash load.

Clothes Washer
Capacity: Compact

(Name of Corporation)
Model(s) SL301, SL309

ENERGYGUIDE

Estimates on the scale are based on a national average electric rate of 4.97¢ per kilowatt hour and a natural gas rate of 36.7¢ per therm

Only compact size clothes washers are used in the scale.

Electric Water Heater

Model with lowest energy cost **$22**

$58 THIS MODEL

Model with highest energy cost **$67**

Estimated yearly energy cost

Gas Water Heater

Model with lowest energy cost **$20**

$22 THIS MODEL

Model with highest energy cost **$24**

Estimated yearly energy cost

Your cost will vary depending on your local energy rate and how you use the product. This energy cost is based on U.S. Government standard tests

How much will this model cost you to run yearly?

with an electric water heater

Loads of clothes per week		2	4	6	8	12
		Estimated yearly $ cost shown below				
Cost per kilowatt hour	2¢	$7	$14	$21	$29	$42
	4¢	$14	$29	$43	$57	$85
	6¢	$21	$43	$64	$86	$129
	8¢	$29	$57	$86	$114	$172
	10¢	$36	$71	$107	$143	$214
	12¢	$43	$85	$128	$172	$256

with a gas water heater

Loads of clothes per week		2	4	6	8	12
		Estimated yearly $ cost shown below				
Cost per therm (100 cubic feet)	10¢	$2	$4	$6	$8	$12
	20¢	$4	$8	$12	$16	$24
	30¢	$6	$11	$17	$22	$34
	40¢	$8	$15	$23	$30	$46
	50¢	$10	$19	$29	$48	$58
	60¢	$12	$22	$34	$44	$68

Ask your salesperson or local utility for the energy rate (cost per kilowatt hour or therm) in your area, and for estimated costs if you have a propane or oil water heater.

Important Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302)

Dishwasher
Capacity: Standard

(Name of Corporation)
Model(s) MR328, XL12, NA83

ENERGYGUIDE

Estimates on the scale are based on a national average electric rate of 4.97¢ per kilowatt hour and a natural gas rate of 36.7¢ per therm.

Only standard size dishwashers are used in the scale.

Electric Water Heater

Model with lowest energy cost **$50**

$60 THIS MODEL

Model with highest energy cost **$84**

Estimated yearly energy cost

Gas Water Heater

Model with lowest energy cost **$19**

$27 THIS MODEL

Model with highest energy cost **$42**

Estimated yearly energy cost

Your cost will vary depending on your local energy rate and how you use the product. This energy cost is based on U.S. Government standard tests

How much will this model cost you to run yearly?

with an electric water heater

Loads of dishes per week		2	4	6	8	12
		Estimated yearly $ cost shown below				
Cost per kilowatt hour	2¢	$8	$15	$23	$31	$47
	4¢	$15	$31	$46	$62	$92
	6¢	$23	$46	$69	$92	$139
	8¢	$31	$62	$92	$123	$189
	10¢	$39	$77	$116	$154	$231
	12¢	$47	$92	$139	$185	$278

with a gas water heater

Loads of dishes per week		2	4	6	8	12
		Estimated yearly $ cost shown below				
Cost per therm (100 cubic feet)	10¢	$2	$5	$7	$9	$14
	20¢	$5	$11	$16	$22	$33
	30¢	$7	$14	$21	$27	$41
	40¢	$9	$19	$28	$36	$55
	50¢	$12	$23	$35	$45	$68
	60¢	$19	$28	$42	$54	$82

Ask your salesperson or local utility for the energy rate (cost per kilowatt hour or therm) in your area, and for estimated costs if you have a propane or oil water heater.

Important Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302)

DISHWASHERS

Dishwasher Energy Guide labels display cost data like the clothes washer labels: two sets of cost data—one for the cost with electric water heating and another for the cost of heating water with gas. Also shown on the charts are operating costs for frequencies of use other than the average 8 loads per week assumed in calculating the Energy Guide number.

ABOUT YOUR ELECTRIC RATE

All Energy Guide labels state the national average electric rate at which the computations were made. Residential electric rates vary widely across the country. Montanans receive electrical power from three main grids, and from some cooperatives. Electric rates in Montana range from 3.4 cents/kWh to 7.5 cents/kWh. Use the figures on your bill to compute your energy costs for the "Yearly Cost" portion of the Energy Guide label.

Life Expectancy/Replacement Chart

The following chart, compiled by Appliance magazine, lists the low, high, and average years of life expectancy of a range of appliances. Life expectancy is based on first-owner use of the product and does not necessarily mean the appliance is worn out. This table may be considered an indication of the "safe life" of new appliances that you would purchase.

	YEARS LIFE EXPECTANCY		
Appliance	**Low**	**High**	**Average**
Dishwashers	8	14	11
Dryers, electric	11	16	13
Dryers, gas	12	16	14
Freezers, Standard	13	20	15
Micro Ovens/Ranges			
Combination Units	11	14	12
Counter Units	10	14	11
Ranges, Free Standing, Electric	13	19	15
Ranges, Free Standing, Gas	11	18	15
Refrigerators, Standard	11	18	13
Washers, Automatic & Semi	9	14	12
Water Heaters, Electric	8	17	12
Water Heaters, Gas	5	13	10
Air-Conditioners, Room	8	14	11
Air-Conditioners, Unitary	9	15	12

(See Chapter VI for life expectancy data on new boilers and furnaces).

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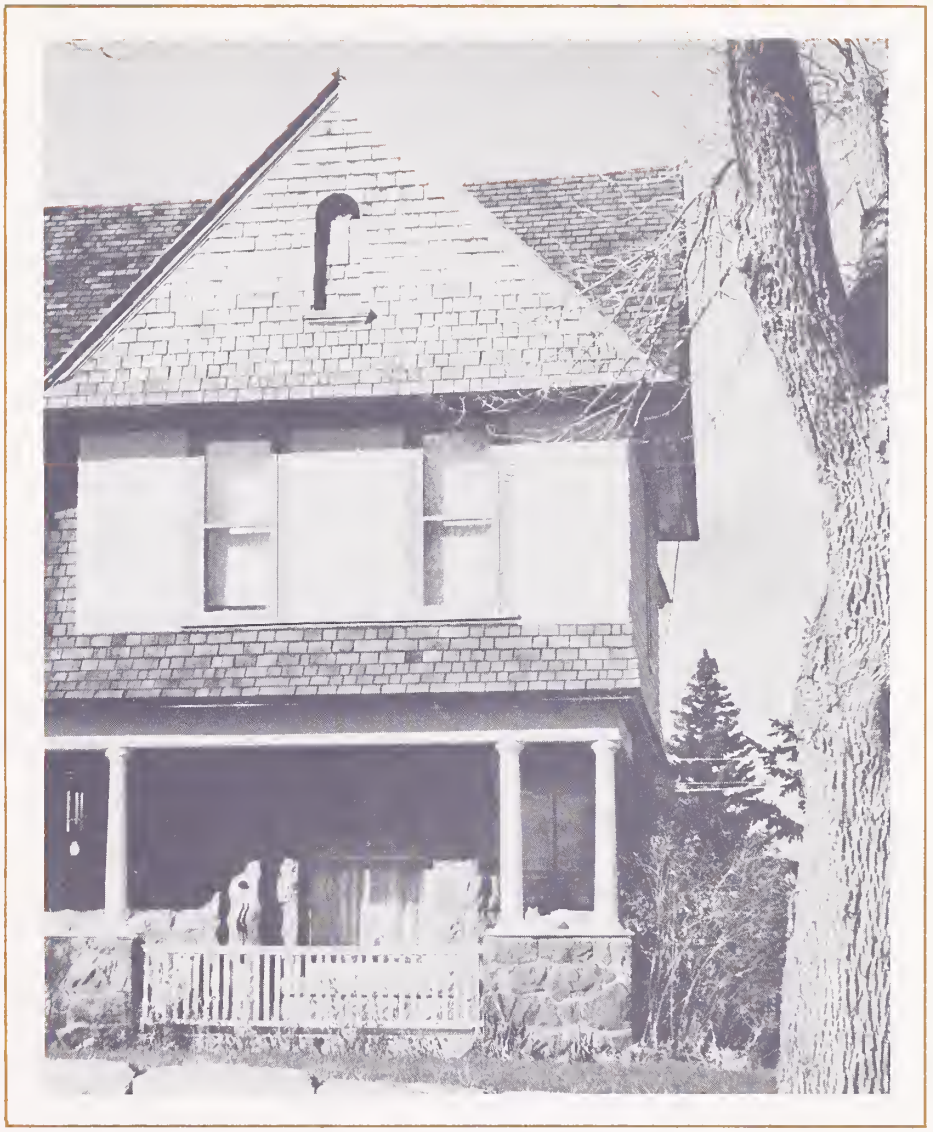
CHAPTER SEVEN

USING MAJOR APPLIANCES WISELY



All of your appliances use energy, but there are a few important things to keep in mind when trying to determine how much they are costing you and how much you can save by using them wisely.

Appliances used to heat or cool cost much more to operate than appliances with only a motor. Ranges, refrigerators, and space heaters cost a lot to operate, but blenders, electric toothbrushes, and vacuum cleaners cost much less. A hair dryer or iron uses a lot of energy while it is in use, but it is on for such a short period of time that the operating cost is relatively small.

Conservation, then, means using large energy-users wisely. You don't need to do without convenient appliances or labor-saving devices; they help make life more pleasant, and energy can be conserved without sacrificing them.

To give you an idea of how much different appliances cost you to operate, consult the following charts.

Electric Appliances

Kitchen

Appliance	Wattage Ratings (Watts)	Estimated Use	Estimated Annual Cost Dollars
Blender	385	20 mins./month	.15
Broiler	1400	1 hour weekly	7.13
Can Opener	180	once daily	0.3
Clock	2	continuous	1.72
Coffee Maker/Automatic			
Brew Cycle	860	twice daily	10.24
Warm Cycle	80	1 hour daily	2.86
Coffee Maker/Drip			
Brew Cycle	1500	twice daily	8.97
Warm Cycle	70	1 hour daily	2.51
Convection Oven	1600	1 hour daily	57.23
Dishwasher (With Heater)	1300	once daily	38.22
Disposal	450	once daily	.26
Food Freezer			
16 cu. ft. manual defrost	350	100 kWh/month	117.60
16 cu. ft. automatic defrost	450	15 kWh/month	176.40
Food Processor	480	20 mins./month	.19
Frying Pan	1200	1 hour weekly	6.12
Hot Plate (two elements)	1250	2 hours/month	2.94
Microwave Oven	1500	30 mins. daily	26.83
Mixer (portable)	125	2 hours/month	.29
Range (surface units & oven)*	12,000	3 times daily	151.90
Self Cleaning Process		once/month	9.42
Refrigerator Single Door			
12 cu. ft.			
Manual defrost	120	50 kWh/month	58.80
Automatic defrost	180	66 kWh/month	77.62
Refrigerator/Freezer			
(Two Outside Doors—Completely Frost Free)			
14 cu. ft.	300	131 KWh/month	154.06
19 cu. ft.	430	188 kWh/month	221.09
(Two Outside Doors only Refrigerator Frost Free)			
12 cu. ft.	250	5 kWh/month	64.68
14 cu. ft.	270	69 kWh/month	81.14
Slow Cooker	200	48 hours/month	11.30
Toaster	1100	twice daily	2.63
Toaster Oven (4 slice)	1500	2 hours/month	3.53
Trash Compactor	400	30 mins. daily	7.15

*Represents average costs for cooking three meals per day using range and oven as needed

Utility/Laundry

Appliance	Wattage Ratings (Watts)	Estimated Use	Estimated Annual Cost Dollars
Clothes Dryer	5000	20 loads/month (45 mins./load)	88.20
Garage Door Opener	350	twice daily	1.67
Iron (Hand)	1100	4 hours/month	5.17
Sewing Machine	75	12 hours/month	1.06
Vacuum Cleaner	600	4 hours/month	2.82
Washer (automatic) (Does not include cost to heat water)	500	20 loads/month (45 mins. load)	8.82

Living Room

Appliance	Wattage Ratings (Watts)	Estimated Use	Estimated Annual Cost Dollars
Light Bulbs/Incandescent			
100 Watts	100	6 hours daily	21.46
60 Watts	60	6 hours daily	12.88
40 Watts	40	6 hours daily	8.58
Light Bulbs/Fluorescent			
40 Watt bulb with ballast	50	6 hours daily	10.73
15 Watt bulb with ballast	18	6 hours daily	3.86
Radio	20	3 hours daily	2.15
Radio/Stereo All	60	3 hours daily	6.44
Television Solid			
Black/White State	55	6 hours daily	11.81
Color	200	6 hours daily	42.92

Bedroom or Bath

Appliance	Wattage Ratings (Watts)	Estimated Use	Estimated Annual Cost Dollars
Electric Blanket*	200	5 months use	14.25
Hair Dryer (hand-held)	1000	10 mins. daily	5.96
Hair Setter/Curler	350	15 mins. daily	3.13
Shaver	15	5 mins. daily	.05
Sunlamp/Heating Lamp (Infrared)	250	15 mins. daily	2.23
Toothbrush	1	15 mins. daily	.01

*Thermostatically Controlled

Heating, Ventilating and Air Conditioning Equipment

Appliance	Wattage Ratings (Watts)	Estimated Use	Estimated Annual Cost Dollars
Air Conditioner (Room)	900-320	400 hours/	36.72-130.56
(Central)	2500-8500	cooling season	102.00-346.80
Dehumidifier	250	7 hours daily/ cooling season	33.79
Attic Fan	375	6 hours daily/ cooling season	27.54
Furnace Fan	300	1600 hours/ heating season	45.60
Window Fan	200	3 hours daily (5 months/year)	9.18
Humidifier	170	360 hrs/heating season	5.81
Water Heater (Quick Recovery)	4500	350 gallons/month/ person for a family of 4 for general use; hot water for automatic clothes washer 6 loads a week @18 gallons per load	414.70**

**One kilowatthour will heat four gallons of water 100°F. The estimated annual cost of $414.70 is based on 7.4¢ per kilowatthour Compare this electric rate with the current rate on your monthly utility bill.

Gas Appliances
Typical BTU/HR Rating
Typical Therm Use & Cost

Appliance	Typical BTU/HR Rating	Estimated Use	Estimated Annual Cost Dollars	
			When heating with gas (1)	Not heating with gas (2)
Clothes Dryer	22,000	20 loads/month (45 mins./load)	$28.51	$36.83
Range	30,000	1 hour daily	78.84	101.84
Outside Grill	35,000	5 hours/week (5 months/year)	25.20	32.55
Water Heater	40,000	350 gallons/month/ person for a family of 4 for general use; hot water for automatic clothes washer 6 loads a week @ 18 gallons per load	230.40	297.60

(1) Based on average cost of 72.0¢/therm for gas house heating customers.
(2) Based on average cost of 93.0¢/therm for customers without gas house heating.

REFRIGERATORS AND FREEZERS

There are several steps that can be taken to help conserve energy when using refrigerators and freezers.

1. If the refrigerator is a manual defrost type, the frost should never be allowed to build up to more than ¼ inch. If it gets thicker, it restricts the air flow and more energy is required.

2. The condenser is the part of the refrigerator that releases the absorbed heat from the inside of the unit into the kitchen area. There must be enough space around the refrigerator so that the condenser can operate efficiently—check the manufacturer's recommendations. Also, consult the operating manual for more specific requirements that may apply to your appliance.

On many refrigerators, the condenser is mounted on the back. This type is called a static condenser. As it is exposed to the air, it is easy prey for dust and lint in the air. Refrigerators with this type of condenser should be cleaned at least twice a year, more often if there are pets in the house because they shed and their hair further impedes the efficiency of operation. To clean a condenser, first unplug the appliance and then vacuum the coils. On some models, the condenser is located on the bottom. Once again, consult the operating manual.

3. All refrigerators have door seals or gaskets to keep cold air inside. If these do not fit snugly, the appliance will not operate at peak efficiency. There is a simple way to determine if these seals are tight enough. If a piece of stiff paper can slide out of the door when it is closed, a new seal may be required. First try to tighten the existing seal by adjusting the small screws that hold it in place. If this does not work, replace the gasket.

4. Open and close the door as infrequently as possible. When you do open it, do not let it stay open.

5. The lower you set the temperature in the appliance, the more it will cost to operate. The recommended temperature for a refrigerator is about 40°F. The freezer compartment should be between 0°F and 10°F. Unfortunately, most refrigerators and freezers do not have a thermostat calibrated for temperature. Therefore, some experimenting is necessary to adjust it properly. A thermometer should be placed in the middle of the appliance and left there for at least 15 minutes. Make sure that it is not resting against any food. The temperature can be adjusted by turning the thermostat dial either toward "colder" or "warmer"; usually changing the dial by one number will increase or decrease the temperature by 10 degrees.

6. Cover all foods in the refrigerator to avoid additional moisture that makes it difficult to cool and contributes to frost build-up. Keep the refrigerator full, but allow enough space so air can circulate. The freezer should be kept between 2/3 and 3/4 full to operate at peak efficiency. When placing unfrozen food in the freezer, no more than 3 pounds per cubic foot of freezer space should be added at any one time.

7. If you are considering buying a new refrigerator or freezer, you might want to invest in one of the new energy-efficient models. The higher initial cost will be justified by lower operating costs. Do not buy a unit that is too large for your needs.

ELECTRIC AND GAS RANGES/OVENS

RANGES

Choosing a gas or electric range depends on what's available, your personal preference, and what type of hookup you already have in your home. If you're switching from gas to electric or vice versa, be sure to figure in the cost of the wiring or plumbing that may be required. It could be significant.

If you decide on a gas range, choose one with an electronic ignition in place of pilot lights. Constantly burning pilot lights use natural gas year-round.

Although a typical range and oven unit consumes only 1/3 the energy of a self-defrosting refrigerator/freezer, there are still many practices that can be followed to ensure maximum efficiency and savings.

1. The most important rule to follow is to use the least heat possible to do the job. To toast a muffin, for example, it would be much more economical to use a toaster oven than to use a full-sized one. Don't peek in the oven and let the heat escape. Don't preheat except when baking, and then preheat only for 10 minutes.

2. When buying a new gas oven or range, make sure it doesn't have constant pilot lights. Most units today rely on an electric ignition system. Also, self-cleaning ovens are usually better insulated.

3. Never use your oven to heat your house. With gas, it can be dangerous as well as inefficient.

4. Keep your range burners and oven clean; accumulated dirt and grease mean inefficiency.

OVENS

Two types of ovens can save you money on operating costs:

— A convection oven uses blower-forced hot air to cook food and recirculates the heated air through the system. Only about 10 percent of the heat is exhausted through the oven vent. Typically, cooking temperatures can be lowered by about 25 percent and cooking times shortened. Gas range models can provide energy savings of up to 40 percent.

— A microwave oven can save money and energy depending upon the type and amount of food cooked, your cooking habits, and how often you use it. CAUTION: If you are a cardiac patient with a pacemaker, check with your physician for special features you'll require to warn against possible radiation leaks.

Microwave ovens use an electron tube called a magnetron to produce the microwaves—a form of electromagnetic energy—that cook the food. Microwaves cook by causing water molecules in food to vibrate rapidly; the friction generated produces heat throughout the food, making it possible to cook quickly.

You can serve food in the dishes it was cooked in, which saves dishwashing.

Microwave cookery is considerably more efficient than conventional oven cooking for preparing TV dinners, frozen casseroles, baked potatoes, chicken and pork roasts, and reheating leftovers.

Some basic rules are:
— The colder the food, the longer it takes to cook.
— As the volume of food increases, the cooking time increases, and
— The denser the food item, the longer it takes to cook or defrost (meat takes longer than bread, for example).

CLOTHES DRYERS

In operating your clothes dryer, you can save a lot of money by shortening the drying time. You can accomplish this in a number of ways: (1) Don't mix articles that need a long drying time with those that require a shorter time. (2) Dry loads one right after another so you can use the heat remaining from the previous load to reduce drying time. (3) Don't overload your dryer. (4) Clean the filter after each use.

DISHWASHERS

About 80 percent of the total annual energy cost for operating an automatic dishwasher goes for heating the water it uses. It's easy to put savings in your pocket by reducing your water heater's temperature to 120°F if your dishwasher has a temperature booster.

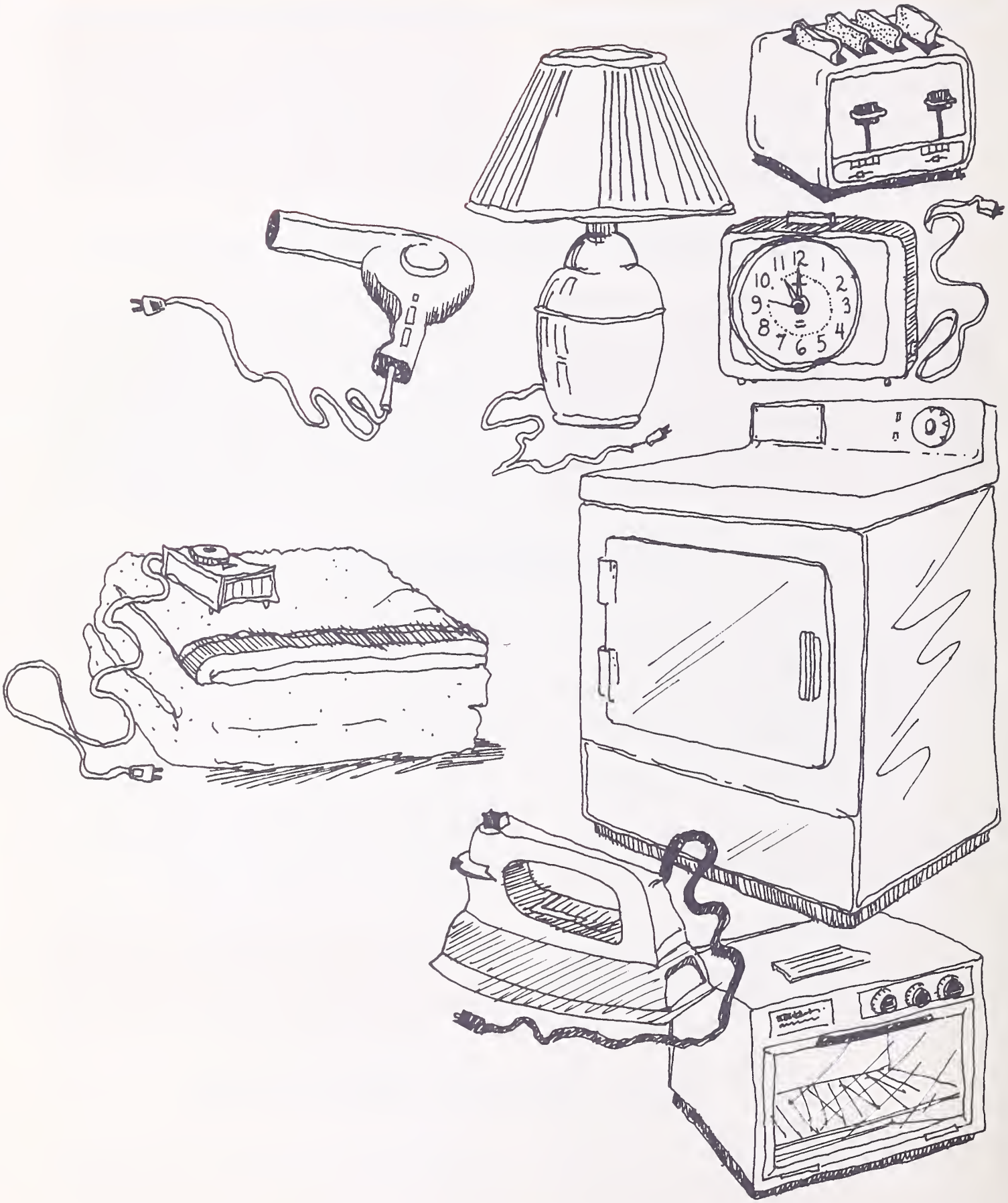
Energy saving dishwashers are built with these features:
— Short cycle selections for lightly soiled dishes. By using less hot water you'll be saving up to 25 percent of water heating energy costs.
— Less hot water use. Models vary as to the amount of hot water used in a cycle of a given duration. You'll have to check the manufacturers' specification sheets for this information.

An air-dry feature that automatically turns off the heat during the dry cycle will save up to 30 percent in electricity costs. Of course you can always turn off the dishwasher manually after the final rinse to achieve the same result, if your dishwasher lacks this automatic feature.

Except for heavily soiled clothes, always wash with warm or cool water. Some lightly soiled clothes can be washed in cold water. Always rinse in cold water, since the temperature of rinse water does not affect cleaning.

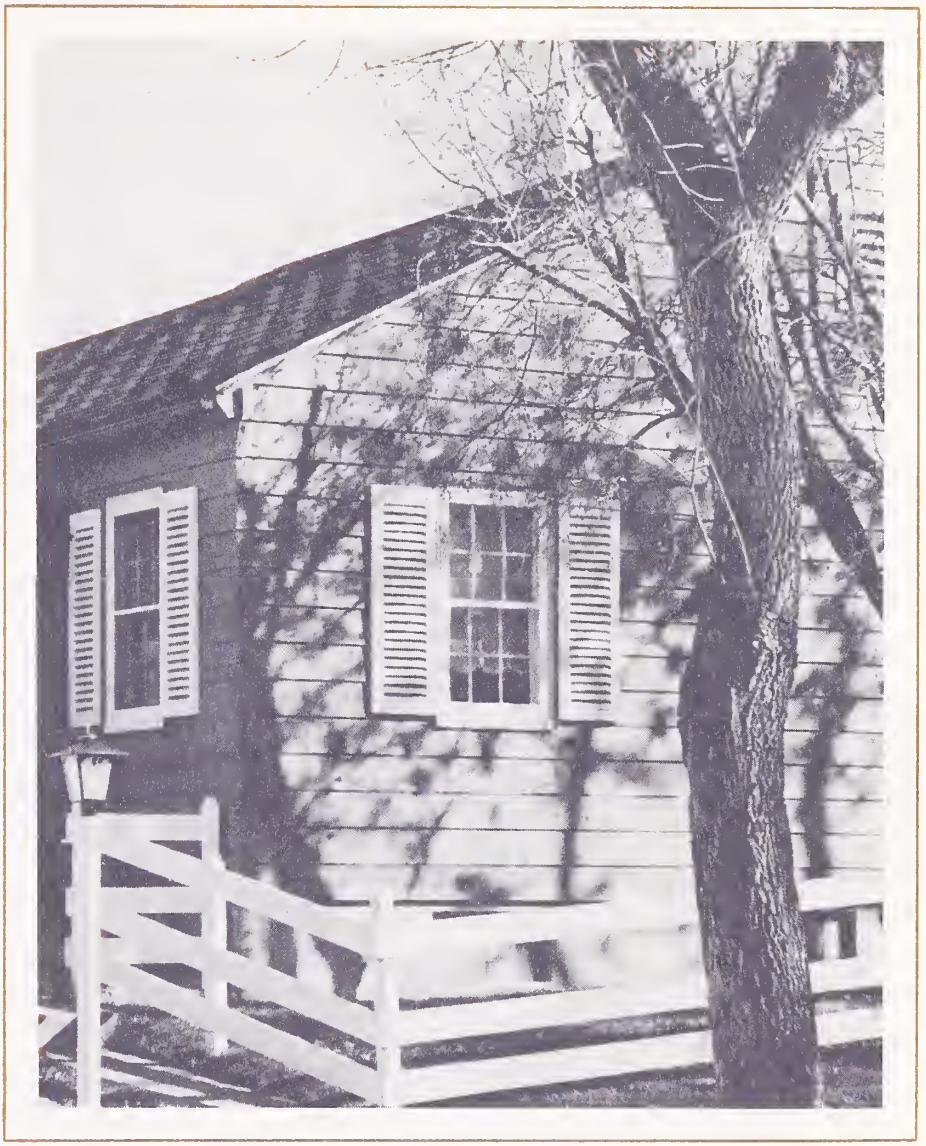
ELECTRIC SPACE HEATERS

If you rely on electric space heaters to supply extra heat in cold rooms or on especially cold days, you should consider that it might be better to weatherize your home to keep it warm than to rely on extra space heaters. If you must use them, however, use them only when needed and don't forget to turn them off when you leave or when the room is warm enough. Purchase heaters with built-in thermostats so the heaters maintain the temperature you want and don't stay on constantly.



CHAPTER EIGHT

LANDSCAPING: PLANTS FOR ALL SEASONS



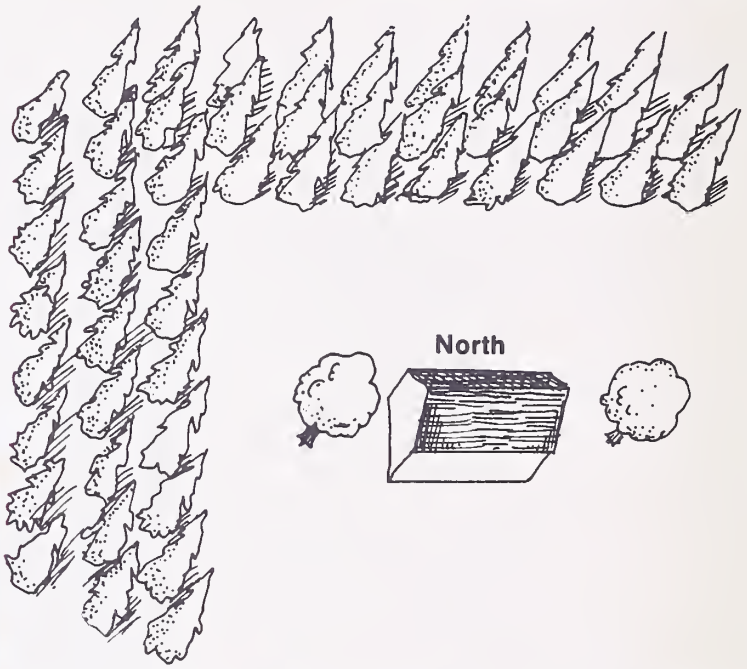
Part of the process of protecting your home from the elements occurs outside your house. Landscaping is decorative and noise-absorbing, and also can help heat and cool your home. Plants can block the sun's heat

in summer and let it in during winter, and can shield your house from wind.

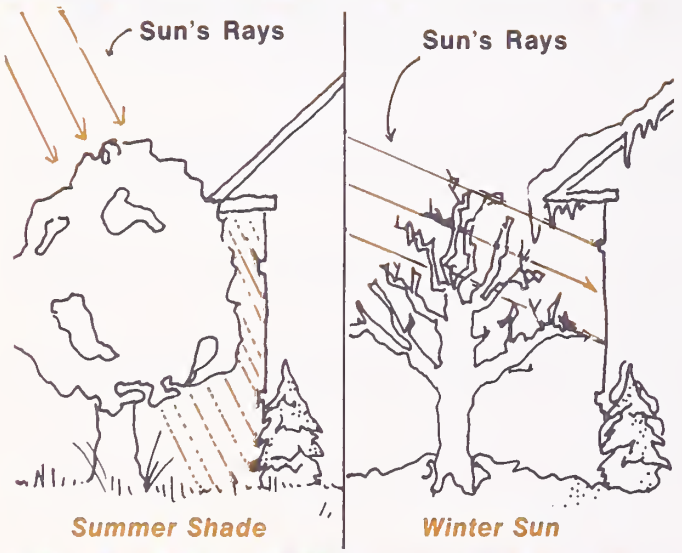
Trees as Windbreaks

Cold winds add to discomfort and heating bills. Strong wind increases the amount of cold air leaking into your house. The colder the air outside the house, the faster heat escapes and the harder your furnace has to work to maintain a constant temperature.

A windbreak can slow the wind that hits your house, reducing the amount of work your furnace has to do. County Extension offices have a wide variety of information regarding windbreaks in specific areas, and should be consulted.



Trees and Solar Gain



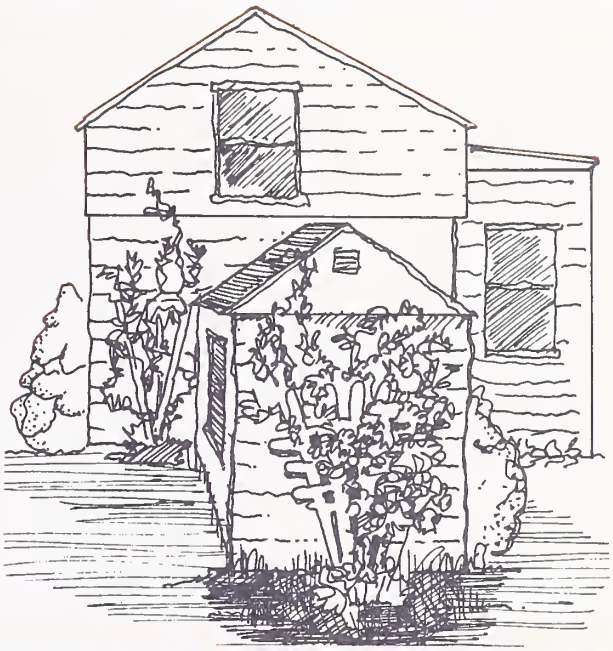
Deciduous trees can shade your house from the sun in the summer. In the winter, the leaves drop to let the sun shine in. Also, plants themselves are mini air conditioners. In full summer greenery, they help cool their surroundings.

Deciduous trees on the southern and southwestern sides of your house provide maximum protection from the summer sun. Even arbors of vines such as Virginia creeper or hops work well. Evergreens, especially blue spruce, are good choices on the western or northwestern side to help protect from the wind in the winter. With them use caragana and Russian olive, which thrive in arid parts of Montana.

Plants as Insulators

Planting vines, shrubs, and other small plants next to your house can help create a dead air space that acts to help insulate the building, slowing the escape of heat in the winter and the entrance of heat in the summer. They also help stop air infiltration. Dense foliage as close to the house as possible is the most effective.

Building small earth berms and topping them with plants also helps with insulation. Place rigid board insulation against the outside of the foundation and place soil against it to produce a slope away from the house. Then plant dense foliage plants that will not grow large enough to cause trouble by being too close to the house or infiltrating water pipes with roots.

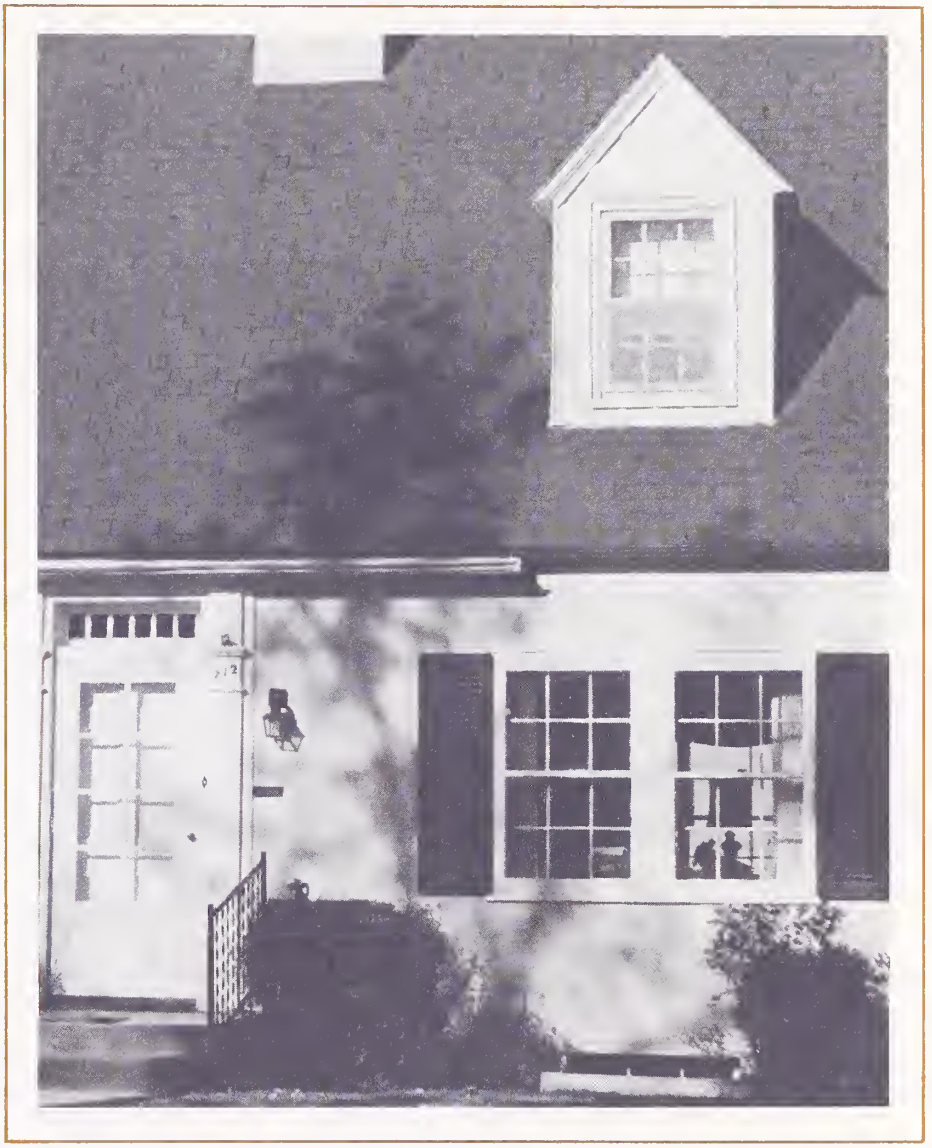


Landscaping is not an alternative to weatherizing your house, but an additional way to help lower energy costs. The amount of money you save depends on the location, type, and condition of your home and on wind and weather conditions.

Remember also that landscaping can be a major undertaking. If you are building a new home or intend to relandscape your present home, you probably would benefit from the ideas presented here. If you are not planning a major landscaping effort, you might still consider a few strategically-placed trellises or vines.

APPENDIX A

INDOOR AIR POLLUTION



Only a few years ago, air pollution concerns pertained mostly to pollution in cities and work places. Now concern has turned to pollution inside homes.

Some pollutants are generated from materials in the home — lumber and

other building materials that have been treated with chemicals, some finishing materials, and certain kinds of insulation. Also, many products used almost daily in the home contain ingredients that irritate eyes, nose, throat, or skin. The earth beneath a house can be a source of radon, a radioactive gas naturally present in soils in many areas.

Other pollutants such as carbon monoxide and nitrogen dioxide from automobile and industrial emissions also reach the indoor air. And here in Montana, many people use wood stoves and gas ranges, which contribute significant amounts of indoor pollution. In most cases, pollutants don't reach harmful levels. As they increase, however, they can affect the health of those who live there.

WHAT CAUSES BUILDUP OF POLLUTION?

New building techniques and higher fuel prices have combined to make tighter houses both possible and desirable. Such houses retain indoor air for longer periods resulting in greater concentration of airborne contaminants in the house.

HOW MUCH IS KNOWN ABOUT INDOOR AIR POLLUTION?

Research on air pollution in general began fairly recently. The Clean Air Act of 1963 focused attention on cleaning up the outdoor air, but little attention was given to indoor air quality, except in industrial settings. Air quality standards have been established for certain pollutants in the outdoor air, but for many years it was assumed that residences sheltered people from these pollutants. Researchers now know that pollution in homes can concentrate to levels beyond those legally allowed in outdoor air.

Major Sources of Pollutants in Homes

- Unvented combustion appliances, such as gas ranges and kerosene and gas space heaters. These appliances emit harmful combustion products directly into the living space.
- Wood stoves and fireplaces. These are usually vented outdoors, but downdrafts or leaks in the chimney, and opening the door on the stove to load it, can cause smoke and other combustion products to contaminate the inside air.
- Tobacco smokers. Tobacco smoke is a major type of indoor air pollution.
- Building materials and furnishings. Urea-formaldehyde insulation can be a major source of formaldehyde. Particle board and plywood used in kitchen cabinets, furniture, and paneling also contain formaldehyde. Other sources are smoking, gas stoves, textiles, some kinds of carpeting, and fabrics treated to make them wrinkle-resistant, fire-resistant, and water-repellant.
- Soil and rock underneath residences are major sources of radon, a radioactive gas.

Different sources may emit pollutants at varying rates. For instance, an improperly adjusted gas range emits higher levels of nitrogen dioxide than a well-tuned one. Products containing formaldehyde release much of their gas when they are new, so recently purchased kitchen cabinets made from particle board, for example, emit higher levels of formaldehyde than cabinets several years old.

The size of a home can make a difference. All else being equal, the smaller the house, the more concentrated the pollution.

Pollutant concentrations also depend on the rate at which air inside the home is replaced by outside air. Since homes are not airtight, outdoor air filters in and indoor air escapes through gaps around doors and windows and through joints and cracks. As indoor air is exchanged for outdoor air, pollutants in the home are diluted and swept outside.

The air change rate, a measurement of the amount of fresh air that replaces indoor air

over a specified period of time, is usually given as average "air changes per hour" (ACH). The more tightly-constructed a residence is, the lower its air change rate will be. Most houses in the Northwest have about 0.75 air changes per hour. Duplexes and apartments have lower air change rates.

Standards for Acceptable Pollutant Levels

Most of us are familiar with air quality alerts as seen on local television news or in daily newspapers. They are based on air quality standards that define the concentrations of pollutants (in parts per million or micrograms per cubic meter) to which most people can be exposed for a given period of time without adverse health effects. Various states and organizations have standards or guidelines for indoor pollutant levels, but Montana has no air quality standards that apply to residences.

The Environmental Protection Agency (EPA) has established standards for a few pollutants in the outdoor air. These standards are designed to "protect the public health...with an adequate margin of safety." However, these standards provide only a rough estimate of acceptable indoor levels. Most people are exposed to indoor pollutants over longer periods of time than they are to outdoor pollutants, and outdoor standards do not always consider the susceptibility of people who are very young, ill, or elderly. Therefore, indoor pollution levels should be lower than allowable outdoor levels to protect health.

HOW WEATHERIZATION AFFECTS POLLUTANT LEVELS

Many weatherization measures, such as ceiling and floor insulation and temperature controls, have no effect on pollutant levels. But "house-tightening" measures—storm windows, weatherstripping, caulking, and blown-in wall insulation—reduce the air-change rate of a residence. If a home already has high pollutant levels, house-tightening measures may increase the risk of health problems.

Indoor Air Pollution Affects Our Health

Even brief exposure to elevated levels of certain pollutants—carbon monoxide, nitrogen oxides, and formaldehyde, for example—can cause eye, nose, and throat irritation and respiratory problems. People may have headaches, dizziness or nausea. They may have trouble breathing or find they tire easily. Their symptoms vary, depending on their sensitivity to a particular pollutant and the level of exposure. Often these effects disappear when the source of the pollutant is removed. (For detailed information on the specific effects of pollutants, see the "Guide to Indoor Pollutants" in this appendix.)

Researchers are concerned about the possible long-range effects of exposure to low levels of certain pollutants, but there is very little information about this problem. It is known that prolonged exposure to nitrogen dioxide and carbon monoxide may lead to chronic respiratory problems. People can develop chronic sensitivity to formaldehyde—an allergic reaction. Long-term exposure to benzo-(a)-pyrene, a tarry substance present in tobacco and wood smoke, and to radon, a gas found in most soil and rock, may increase the risk of lung cancer.

As yet, very little is known about the effects of long-term exposure to low levels of pollutants found in homes. Although studies are underway, research is still in its preliminary stages. The picture is further complicated by the exposure of people to many pollutants, making it

difficult to isolate and analyze the effect of any single pollutant.

Most of what is known about the long-range health effects of pollutants comes from studies of workers exposed to high levels of pollutants on the job. These workers developed a range of medical problems, including respiratory diseases and cancer. But pollutant levels in the work places studied were many times higher than those found in homes. Also, researchers think it possible that other factors in the working environment contributed to workers' illnesses. Further, those particular workers—most of them adult males and many of them smokers—are not typical of the general population.

Until these uncertainties are resolved, scientists must be cautious. They assume that if pollutants can cause health problems at high exposure levels, there is a proportionate risk at low exposure levels.

HOW TO REDUCE INDOOR AIR POLLUTION

Removing the source of a pollutant is the simplest way to control sources in your home. In many cases, a less hazardous alternative can be found. For example: Substitute an electric space heater for a kerosene space heater. When you remodel, avoid using products that emit formaldehyde. Ask friends not to smoke in your home.

When it isn't practical to remove a pollutant source from your home, control it through ventilation, air-cleaning, or blocking off part of the source. Install an exhaust fan for a gas range to reduce your exposure to nitrogen dioxide and carbon monoxide. When using household chemicals, open windows to increase ventilation. Change furnace filters frequently to remove particles from the air. Seal cracks in basement walls and floor to control radon. You can increase ventilation without giving up energy savings by installing an air-to-air heat exchanger.

Monitoring Pollutant Levels in the Home

Techniques to measure pollutant concentrations in residences have been developed, but in many cases they involve complicated and expensive equipment, time, and technical expertise.

There are, however, a few relatively inexpensive, easy-to-use devices that you can use in your home. Pollution detectors are available for formaldehyde, radon, and nitrogen dioxide. These simple devices can be installed in your home and left for a period of time. They are then analyzed by a laboratory. The results tell you the average pollutant level during the monitoring period.

You can then compare this level to existing standards, typical concentrations found in homes, and to levels known to cause health problems. These comparisons won't give you precise information, but they can help you decide if your home has a pollution problem. (For further information on monitors, standards, and pollution levels found in homes, see the sections on individual pollutants in the following "Guide to Indoor Pollutants.")

GUIDE TO INDOOR POLLUTANTS

Radon

Radon is an odorless, colorless gas that comes from radium, a naturally occurring element in soil and rock. The amount of radon present in the soil varies widely.

SOURCES

In the Pacific Northwest, most of the radon found in homes comes from the soil beneath the residence. Radon, being a gas, passes readily through cracks and holes in the foundation. It also diffuses, though more slowly, through concrete. As radon travels upward, it enters the living area through cracks and openings in the walls and floors.

Well water may also be a source of radon. Unlike municipal water, well water is usually not exposed to the air before it is used indoors. When a faucet is turned on inside a home, radon in the water passes into the air. Natural gas, though it is considered a minor source, may also pick up radon in the ground and carry it into a home.

To some extent, building materials such as concrete, brick, and phosphate slag may contain radon. Insulation made with phosphate slag was used in residences in Washington State. Phosphate slag was widely used between 1962 and 1977 in the concrete foundations of homes built in southeastern Idaho. Earthen homes and solar-heated structures with rock heat storage may also have high radon levels because of the additional earth and rock used in their construction.

MEASUREMENT AND STANDARDS

Radon does not remain a gas for very long. It quickly breaks down, or decays, into several elements called "radon daughters." Two of these elements generate radiation as they quickly decay.

To date, there has been no standard set for residential indoor radon in Montana. Nationwide, various organizations have proposed a range of guidelines and standards, as shown in the table. Occupational standards are included for comparison.

Radon Standards and Guidelines

Organization	Recommended Maximum Radon Level	Comments
U.S. Mine Safety & Health Administration	16 pCi/l*	Regulation for Miners
National Council on Radiation, Protection, and measurement	8 pCi/l	Recommended Action Level for general population
BPA	5 pCi/l	Action Level for Residential Weatherization Program.
Environmental Protection Agency	4 pCi/l	Indoor radon in homes built on sites contaminated by uranium processing.
American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)	2 pCi/l	Recommended exposure level in commercial buildings and residences

*picoCuries per liter of air

HEALTH EFFECTS

Prolonged exposure to radon and its decay products may increase the risk of lung cancer. The scientific community is not certain that there is a significant risk of lung cancer at very low levels of exposure, but, faced with uncertainties, researchers prefer to err on the safe side in estimating health risks. They believe that about 5 percent of all lung cancer is due to radon. Smoking accounts for about 80 percent of all lung cancer.

RADON LEVELS IN HOMES

The amount of radon that reaches the living space of a home depends in part on the home's

characteristics. If there is a ventilated crawl space between the ground and the living area, some of the radon will escape outdoors. If the home's foundation or basement is flush with the ground, radon will pass readily through cracks and holes in the foundation and enter the living space.

Air change rates also are important. Radon will escape more quickly from a house with 1 air change per hour than from a house with 0.5 air change per hour.

MONITORS

Radon measuring devices are commercially available. These lightweight plastic monitors, about the size of a wristwatch, are installed in a home for several months and then mailed to a laboratory for analysis.

Reducing Radon Exposure

1. Increase Natural Ventilation

Open doors and windows periodically. Open all existing crawl space vents and make new crawl space vents.

2. Install an Air-to-Air Heat Exchanger

Air-to-air heat exchangers are mechanical devices that maintain a home's air change rate while conserving energy. These devices draw in fresh air from outside the home and exhaust stale air from inside. In winter, heat from the warm air leaving the home preheats the colder incoming air. This process recovers about 50-70 percent of the heat lost when indoor air leaves the house.

These exchangers can be installed in walls or windows, or as part of a central air system. To be effective, however, they must be properly sized. Two or more wall or window units may be required for a large house. A properly-sized air-to-air heat exchanger can maintain a home's air change rate after house-tightening measures are installed and can capture about 90 percent of the energy savings from house tightening. Sizing can be tricky however, and heat exchangers are not cheap, so talk to a qualified heat contractor before taking this step.

3. Reduce Radon Entry

In homes with a crawl space:

Seal cracks and holes in the foundation.

Caulk around pipes and ducts where they penetrate the floor.

If your home has a basement:

Seal visible cracks in the basement floors and walls with caulking, epoxy, or other sealants.

Seal basement drains.

Install insulation in the basement ceiling.

If your home has a partial basement and partial crawl space:

Construct an airtight, insulated partition between these spaces.

Ventilate the crawl space.

Although all these methods are expected to help reduce radon concentration in a home, little scientific evidence is available on their overall effectiveness.

Formaldehyde

Formaldehyde is a pungent, irritating, colorless, water-soluble gas. A low-cost chemical with excellent bonding characteristics, formaldehyde is found in urea-resins used to manufacture building materials and textiles. Formaldehyde is also a component of ureaformaldehyde (UF) foam insulation injected into walls, primarily in the early 1970s.

SOURCES

UF foam insulation, particle board, plywood, fiberboard, furniture, drapes, and carpeting are the primary sources of formaldehyde pollution. Some formaldehyde is also produced during combustion in gas stoves, wood stoves, and tobacco, though these are minor sources.

The amount of formaldehyde released from UF foam varies. When improperly compounded or installed, UF foam can emit significant levels of formaldehyde. UF foam has been banned in Canada, and in 1982 the U.S. Consumer Product Safety Commission (CPSC) imposed a nationwide ban on UF foam. Although that ban has since been overturned by a court ruling, the controversy over UF foam has all but stopped its manufacture. Mobile homes generally have higher levels of formaldehyde than other dwellings because they have a small living area, a low air-change rate, and usually contain more particle board and plywood. Many of the complaints about irritating effects of formaldehyde have come from residents of mobile homes.

MEASUREMENT AND STANDARDS

Formaldehyde in the air often is measured in parts per million (ppm).

No standard has been established for formaldehyde exposure in residences. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) has recommended 0.1 ppm as the maximum level for continuous indoor exposure. The National Academy of Sciences has concluded that exposures to about 0.25 ppm is not irritating to a large majority of the healthy adults in the United States.

HEALTH EFFECTS

Formaldehyde in sufficient concentration is highly irritating to skin, eyes, mucous membranes, and respiratory tract, even in short-term, low exposures. These health problems usually stop as soon as exposure stops.

Individual sensitivity to formaldehyde varies. About 10 to 20 percent of the population appears to be highly sensitive to formaldehyde at low levels. Some people report mild eye, nose, and throat irritation at concentrations less than 0.5 ppm, while others note these symptoms at concentrations as low as 0.25 ppm. Low concentrations can also cause asthmatic symptoms in some susceptible people, and chronic exposure can make people more sensitive to formaldehyde.

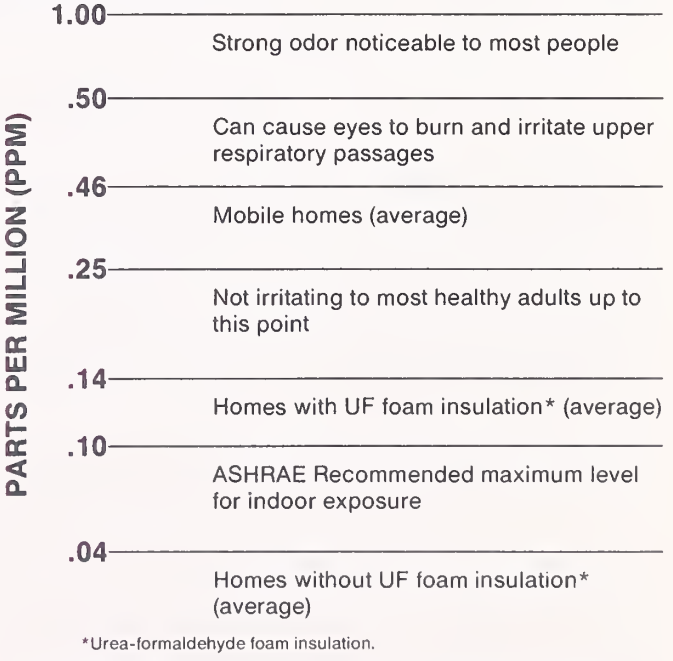
Exposure to 1 to 2 ppm may cause headaches, nausea, coughing, constriction in the chest, rapid heartbeat, and a feeling of pressure in the head. Over a long period of time, exposure to formaldehyde may cause changes in the respiratory system.

Studies have shown that formaldehyde can produce nasal cancer in animals. To date, however, there is no direct evidence that formaldehyde causes cancer in humans. Nevertheless, to minimize potential health risks, the Federal Panel on Formaldehyde and several federal agencies have concluded that formaldehyde should be considered a carcinogen until information to the contrary is available.

FORMALDEHYDE LEVELS IN HOMES

Because of the range of products containing formaldehyde, it is impossible to predict what level of formaldehyde would be found in a given residence. On-site measurements would be necessary. However, limited measurements indicate a range of formaldehyde concentrations likely to be found in homes.

Formaldehyde Concentrations



*Urea-formaldehyde foam insulation.

Source: Gupta et al., "Formaldehyde in Indoor Air: Sources and Toxicity," Environment International

If a home has a high level of formaldehyde, the occupants are likely to be aware of it. Most people notice the strong odor of formaldehyde at about 1 ppm. Some people can smell formaldehyde at much lower concentrations.

The rate at which formaldehyde is released from materials varies. As products containing formaldehyde age and cure, they emit less formaldehyde. Though the rate is not well defined, it appears that half the formaldehyde contained in most materials is released in about 4 years. Formaldehyde levels also increase with higher temperatures and humidity. Relatively high levels of formaldehyde are likely to be found in tightly-built new homes, where new materials are releasing gas at a high rate.

MONITORS

An inexpensive, easy-to-use formaldehyde monitor is available to consumers. This small measuring device is placed in a room for a few days and then mailed to a laboratory for analysis.

Reducing Formaldehyde Exposure

The amount of formaldehyde in plywood and particle board varies. Use exterior-grade plywood, which releases less formaldehyde. Look for low-formaldehyde ("low-fuming") particle board. It may be difficult to find since it is not widely available.

Increasing air exchange rates and using a dehumidifier may reduce formaldehyde concentrations in indoor air. USDOE is funding efforts by the Lawrence Berkeley Laboratory to develop techniques for removing formaldehyde from indoor air.

COMBUSTION GASES

Carbon monoxide and nitrogen oxide are formed during combustion, and can cause health problems at high concentrations.

Carbon Monoxide

Carbon monoxide is a colorless, odorless gas. It is a product of incomplete combustion of natural gas, oil, wood, coal, tobacco, and other materials. Carbon monoxide increases when there is an inadequate supply of combustion air, as is often found in improperly maintained wood stoves, gas stoves, oil stoves, and furnaces.

SOURCES

Unvented kerosene space heaters, wood stoves, gas stoves, and tobacco are major sources of carbon monoxide. Faulty furnaces and automobile exhaust fumes from garages attached to homes are lesser sources, but they can contribute significant amounts of carbon monoxide to indoor air.

MEASUREMENT AND STANDARDS

No federal or state standards exist for carbon monoxide in residences. Japan, the only country with a standard for carbon monoxide in nonoccupational indoor environments, has set a limit of 10 ppm for continuous exposure. The EPA standard for maximum allowable level of carbon monoxide in outdoor air is 9 ppm exposure averaged over eight hours, and 35 ppm for a one-hour average exposure. This standard has a safety margin built in to protect people with angina. These people have inadequate blood and oxygen flow to the heart, so they are especially sensitive to any interference with the body's ability to absorb or distribute oxygen, which is a characteristic of carbon monoxide.

HEALTH EFFECTS

Carbon monoxide interferes with the delivery of oxygen throughout the body. Mild oxygen deficiencies can affect vision and brain function. Exposure to concentrations of carbon monoxide 10 to 20 times greater than that generally found in homes can cause headaches and irregular heart beat. Higher concentrations can cause nausea, weakness, confusion, and death. Carbon monoxide poisoning from faulty oil and gas furnaces and from cars left running in attached garages cause several deaths each year.

CARBON MONOXIDE LEVELS IN HOMES

The average carbon monoxide concentration in homes typically varies between 0.5 and 5 ppm. Cooking over a gas stove can add 5 to 10 ppm to the existing level. Concentrations of 22 ppm and 39 ppm have been measured for poorly adjusted gas stoves.

Unvented gas or kerosene heaters can emit high levels of carbon monoxide. In laboratory tests, a convective kerosene heater produced carbon monoxide levels of 50 ppm after 45 minutes, even though the laboratory air change rate was twice that found in a typical house. Several states have banned residential use of kerosene heaters. In Montana, testing is continuing under the direction of the state Occupational Health Bureau of the Department of Health and Environmental Sciences. (See the discussion on nitrogen oxide levels.)

Nitrogen Oxides

SOURCES

The major sources of nitrogen oxides are unvented gas stoves and kerosene space heaters. The high outdoor concentrations of nitrogen oxides sometimes found in highly industrialized areas can also raise indoor concentrations.

MEASUREMENT AND STANDARDS

There are no indoor standards for nitrogen oxide.

HEALTH EFFECTS

Nitrogen oxides can irritate skin, eyes, and mucous membranes. Depending on the level and duration of exposure, respiratory effects range from slight irritation or burning and pain in the chest to violent coughing and shortness of breath.

Prolonged exposure to 50 ppm of nitrogen dioxide can cause lung damage and chronic lung disease, but the scientific community does not agree whether prolonged exposure to low levels of nitrogen oxides can cause chronic respiratory illness. Information on chronic nitrogen oxide poisoning is extremely scarce because (1) symptoms do not appear until a critical concentration is reached, (2) respiratory damage develops slowly, and (3) it is difficult to isolate the effects of nitrogen oxides from those of associated pollutants. Research on the health effects of exposure to low levels of nitrogen oxides is continuing.

NITROGEN OXIDE LEVELS FOUND IN HOMES

Nitrogen dioxide concentrations equal to or greater than EPA's standard for outdoor air (0.05 ppm) are fairly common in kitchens where gas is used for cooking. Measurements indicate that typical levels in kitchens with gas stoves range from 0.025 to 0.08 ppm. Concentrations in homes without gas appliances would be the same as the outdoor level. Nitrogen dioxide in the outdoor air comes largely from motor vehicle and industrial emissions.

Unvented space heaters are major sources of nitrogen dioxide. In laboratory tests, nitrogen dioxide concentration from a convective kerosene space heater reached 1 ppm after 45 minutes—about 20 times the EPA standard for *outdoor* air.

MONITORS

The Lawrence Berkeley Laboratory is working to develop an inexpensive, easy-to-use monitor for carbon monoxide. Measuring devices for nitrogen oxides are currently available.

Reducing Exposure to Combustion Gases

Make sure that all household combustion appliances are vented to the outside. Don't vent oil or gas heaters into crawl spaces. When using combustion appliances, provide cross-ventilation by opening two opposite windows. Install an air-to-air heat exchanger. Make sure that gas appliances are properly adjusted and leak-free. Call your gas company for assistance. Have fireplace flues and chimneys inspected and cleaned frequently. Make sure that wood stoves are installed correctly. Do not let fires smolder. If you have an attached garage, NEVER leave your car engine running inside it.

RESPIRABLE SUSPENDED PARTICULATES (RSP)

Respirable suspended particulates (RSP) are airborne particles or fibers small enough to be inhaled. These particles can lodge in the lungs and irritate or damage lung tissue. Many different types of these are found in homes, including soap powders, pollen, lint, and dust.

Benzo-(a)-pyrene (BaP), a combustion by-product, has been studied extensively. This particulate is discussed in the next section of this appendix.

Asbestos is a mineral fiber used mostly before the mid-1970s in a variety of construction materials. While chronic exposure to asbestos has led to respiratory diseases and cancer in workers, exposure to asbestos in the home normally occurs only when asbestos materials are disturbed and the fibers are released into the air. Remodeling in a home or removing asbestos materials is the only significant source of exposure. House-tightening is unlikely to affect your exposure to asbestos.

SOURCES

Tobacco smoking is the source of most respirable suspended particulates in most homes. Wood smoke, unvented gas appliances, and kerosene space heaters also produce RSP.

MEASUREMENT AND STANDARDS

Airborne RSP normally is measured in micrograms per cubic meter. There is no standard for respirable suspended particulates.

HEALTH EFFECTS

Particulates are composed of many compounds which at elevated levels can irritate eyes and mucous membranes. They also can carry gasses or other substances into the lungs. Respiratory illnesses, especially chronic illnesses such as bronchitis and emphysema, are linked to exposure to particulates.

Cigarette smoking is believed to cause lung cancer, emphysema, and heart disease in smokers and recent studies indicate it can affect the health of nonsmokers. Smoke inhaled by nonsmokers can irritate the eyes, nose, and throat. It also can cause respiratory infections and aggravate the condition of people with allergies or with heart or lung disease. Studies have linked parental smoking with respiratory illness in children.

RSP LEVELS FOUND IN HOMES

Concentrations of RSP in homes where there are no smokers are likely to be about 20 micrograms per cubic meter. Monthly concentrations of RSP in a home with one smoker have been measured at about 40 micrograms per cubic meter. In the same study, homes with two or more smokers had an average monthly RSP concentration of 75 micrograms per cubic meter.

BENZO-(a)-PYRENE

Benzo-(a)-pyrene (BaP) is a tarry, organic particle generated by incomplete combustion.

SOURCES

Wood stoves and tobacco smoking are the major sources of BaP.

MEASUREMENT AND STANDARDS

Benzo-(a)-pyrene is measured in nanograms (one-billionth of a gram) per cubic meter (ng/m^3). No standards or guidelines for allowable BaP concentration have been established.

HEALTH EFFECTS

Benzo-(a)-pyrene is a carcinogen. For a nonsmoker, the risk of lung cancer from exposure to 2.2 ng/m^3 of BaP for life, the amount estimated for single-family homes with a wood stove and two occupants who smoke, is roughly equivalent to the risk of a fatal accident after driving a car for approximately 94,300 miles.

Reducing RSP and BaP Exposure

If you smoke indoors, smoke near an open window. Be sure that wood stoves are properly installed with a tight-fitting stovepipe that has no cracks or leaks. Vent all combustion appliances to the outdoors. Increase ventilation by opening windows or installing an air-to-air heat exchanger. Change filters regularly on forced-air heating or cooling systems.

HOUSEHOLD CHEMICALS

Many of the chemicals used in household cleaners, pesticides, and materials contain toxic substances. These chemicals are often referred to as "organic compounds" because they have a carbon base.

SOURCES

Synthetic materials used in carpeting, wall covering, linoleum fabrics, rubber, and plastic emit organic compounds as they age and deteriorate. Adhesives, cleaning agents, paints, personal hygiene products, and waxes contain solvents that evaporate into the air. Natural gas, tobacco, wood, and other materials emit organic gases and particles during combustion. Pesticides, insecticides, and herbicides contain a variety of toxic chemicals. Aerosol sprays contain propellant gases, such as propane, butane, and nitrous oxide.

HEALTH EFFECTS

Household chemicals contain such a wide variety of organic compounds that health effects are difficult to assess. Each compound has different effects, and when products are combined, they may interact and produce still other health effects. Some compounds are irritants, others cause cancer. Some affect the central nervous system, some interfere with metabolic processes.

CONCENTRATIONS FOUND IN HOMES

Concentrations of organic compounds in homes are generally well within safe occupational exposure levels established by the Occupational Safety and Health Administration (OSHA). However, the OSHA standard was designed for an industrial setting where

workers are exposed to high levels of single compounds. In homes people are likely to be exposed to low concentrations of several compounds at the same time. As yet researchers know very little about the combined effects of organic compounds or the effects of low exposure levels.

Reducing Exposure to Household Chemicals

Before using household chemicals, read the labels carefully. Products usually carry warnings and instructions for use aimed at reducing exposure. Use chemicals only in well-ventilated areas. Gases and vapors can leak from containers. Store household chemicals in a well-ventilated place, such as a garage or outdoor shed. Substitute less hazardous products for household chemicals. For instance, use a liquid or dry form of a product rather than aerosol sprays. Ventilate or clean a room to control odors rather than use a room deodorant.

APPENDIX B

FOR MORE ENERGY INFORMATION

The Energy Division of the Department of Natural Resources and Conservation, working with the Montana Cooperative Extension Service, has set up 60 Energy Information Centers around the state. The centers offer over 50 free publications on

energy conservation and renewable energy sources. For the location of the nearest Energy Information Center, call your County Extension office.

The following free publications are available at the Energy Information Centers or from the Energy Division, DNRC, Capitol Station, Helena, MT 59620.

Building the Ideal Home. The ideal home described in this book includes a high level of insulation, passive solar orientation, a continuous vapor barrier, and an air-to-air heat exchanger to keep indoor air fresh.

Developing Hydropower in Montana—A Guide to Permitting and Licensing. The Montana Joint Water Resources Research Center produced this handy step-by-step guide for obtaining the proper permits before building a hydroelectric system in Montana.

Energy Activities with Energy Ant.
lar coloring booklet provides fun for the kids while teaching them about energy and how to use it wisely.

Guide to the Renewable Report Library. Abstracts of the final reports on the major DNRC-funded renewable energy projects are included in this guide. Copies of the full reports can be borrowed from the Montana State Library.

Hot Water—Insulate and Save! One of the most cost effective measures you can take is to insulate your natural gas or electric water tank. This guide leads you step-by-step with a series of photos that shows you exactly what to do.

How to Reduce Energy Costs in Your Building. This 54-page book offers energy- and money-saving tips for businesses. The emphasis is on techniques that are simple and don't require capital investments.

Major Energy Conservation Retrofits: A Planning Guide for Montanans. This 72-page guide shows builders, architects, and skilled home owners state-of-the-art strategies for insulating roofs and walls. Determining the most cost-effective ways to increase the thermal efficiency of building envelopes is also covered.

Managing Your Solar Greenhouse. Written specifically for Montana, this book describes how to operate your solar greenhouse to produce the best vegetables ever. Sections on pest control, plant varieties suitable for Montana's greenhouse climate, and construction tips are provided.

Map of Geothermal Resources of Montana. This full-color map shows all the known hot springs and hot-water wells in the state, complete with water temperatures and water chemistry. Included are inserts describing the many different uses of geothermal energy in Montana, as well as descriptions of areas that have high potential for future geothermal discoveries.

Microhydro Power—Reviewing an Old Concept. One of the best guides available for quickly determining whether you've got enough energy in your stream to generate power. Easy-to-follow instructions on measuring flow, head, and power, plus a good overview on types of hydro equipment available.

Mobile Home Energy Savings. "Keep comfort up and costs down" is the theme of this 61-page book. It shows how to keep pipes from freezing in the winter; wrap your water heater with a blanket of insulation; stop drafts; skirt, side, and insulate; use vapor barriers to protect your insulation; and get the most out of your swamp cooler.

Moisture and Home Energy Conservation. This 34-page book tells how to detect, prevent, and correct moisture problems in the home.

Montana Energy Tax Benefits. This guide covers the state and federal tax credits and exemptions for energy conservation and renewable energy.

Montana Sunpower, Passive Solar Homes. Samples of cost-effective passive solar homes and greenhouses that have been built in Montana are described in this book. Building materials, construction techniques, and system performance are covered.

Montana's Energy Resources is a series of 8-page brochures. Each brochure describes how an energy resource is being used in

Montana, gives a brief introduction to the technology and includes a suggested reading list. The series includes books on wind, small-scale hydro, geothermal, and alcohol fuel.

Solar Domestic Hot Water. Solar hot water systems are appearing on the rooftops of homes in many Montana communities. This book describes the basic types of solar hot water systems, discusses their pros and cons in Montana's climate, and gives installation tips. An excellent solar hot water bibliography is also included.

Sunspaces—A Montana Guide. Sunspaces are one of the most popular solar energy projects in Montana. This guide describes the basic components of a sunspace, tells how to properly site your sunspace, how to calculate your solar energy gain, and where to go for more detailed information.

The Montana Energy Resources Guide. Designed for teachers and youth group leaders, the guide lists sources of speakers, films, videotapes, slide shows, and publications on energy conservation and renewable energy resources.

Using the Earth to Heat and Cool Homes. This 22-page book discusses the installation, economics, reliability, and performance of heat pumps that use low-grade geothermal energy and earth-tempered air to heat and cool homes.

Window Insulation: How to Sort Through the Options. This 34-page book shows how to make your home more comfortable and save money on your energy bills with insulating window treatments. The book describes the window insulation products available, as well as how to size up your window insulation needs, how to choose the right design for each window, and how to figure how much energy window insulation products save.

Wood Heat. This booklet discusses one of the most popular heating options in the state. Included is information on the latest high-efficiency wood stoves, air pollution concerns in Montana, choosing the right wood, safe installation techniques, and the economics of woodburning.

Other Sources of Free Information

Your city or county library offers a wealth of information on all energy subjects. Your local utility can provide information on home energy conservation. Hardware stores and lumber suppliers can help explain the proper use of the many energy-saving products they sell.

The National Appropriate Technology Assistance Service answers questions about energy conservation and renewable energy resources over its toll-free lines. For assistance call 1-800-428-1718 in Montana from 8 a.m. to 5 p.m. weekdays, or write NATAS, PO Box 25254, Butte, MT 59702-2525. The service is for home owners, renters, energy innovators, small businesses, farms, state and local governments, non-profit organizations and educational institutions. It's operated by the National Center for Appropriate Technology for USDOE.

Good Neighbor Referral

☐ Please send a FREE copy of *The Montana Energy Book* with my compliments to the person below.

Send to:

NAME

ADDRESS

TOWN ZIP

Compliments of:

YOUR Name

(Print or sign your name on the line above since we'll include this referral slip along with the booklet in the mail.)

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